

Perception

DSC 106: Data Visualization

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Announcements

Lab 3 due Friday.

Project 2 checkpoint due this coming Tuesday.

FAQs:

1. What if I want to customize my website for Lab 3 (and onwards)?
Feel free, as long as you can include all required talking points in your video.
2. For Piazza posts, all parts must relate to lecture topics from that past week (e.g. Perception, Color this week)

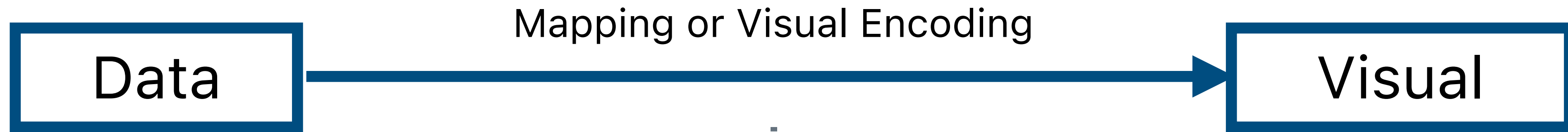
Project 2: Persuasive Visualization

Task: Create two static visualizations. One argues **for** a proposition. One argues **against**.

Persuade your reader of your arguments using both earnest and deceptive techniques.

Should be hard to tell when you're being deceptive! Can't lie (e.g. change data values).

You will peer review 3 other students' submissions.



Expressiveness

A set of facts is *expressible* in a visual language if the sentences (i.e. the visualizations) in the language express *all the facts in the set of data, and only the facts in the data.*

Effectiveness

A visualization is more *effective* than another if the information it conveys *is more readily perceived* than the information in the other visualization

Channels: Expressiveness Types and Effectiveness Ranks

➔ Magnitude Channels: Ordered Attributes

Position on common scale



Position on unaligned scale



Length (1D size)



Tilt/angle



Area (2D size)



Depth (3D position)



Color luminance



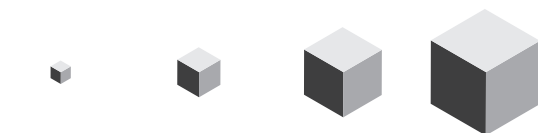
Color saturation



Curvature



Volume (3D size)



Same

Same

Same

➔ Identity Channels: Categorical Attributes

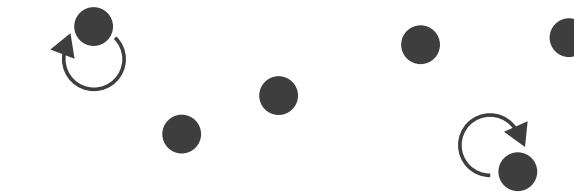
Spatial region



Color hue



Motion



Shape



Most
Effectiveness
Least


Tamara Munzner, *Visualization Analysis and Design* (2014).


Channels: Expressiveness Types and Effectiveness Ranks

➔ **Magnitude Channels: O or Q attributes**

Position on common scale 

Position on unaligned scale 

Length (1D size) 

Tilt/angle 

Area (2D size) 

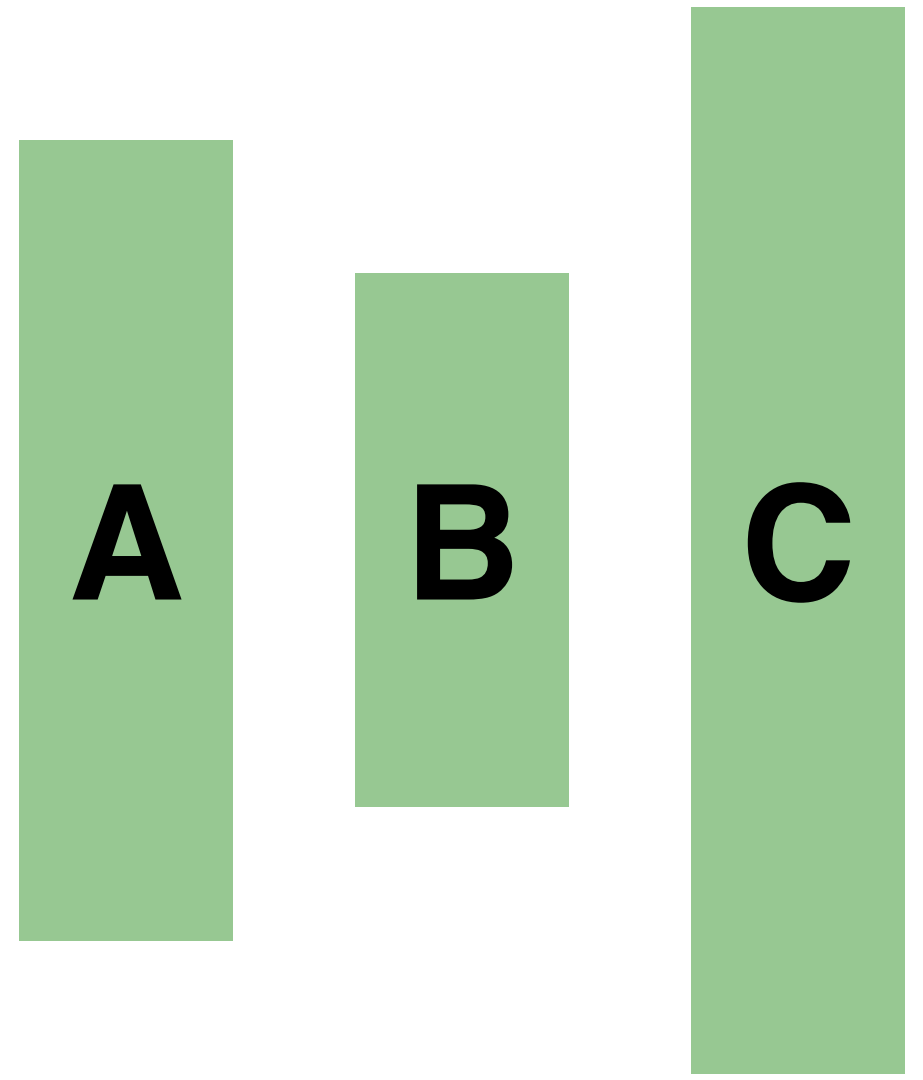
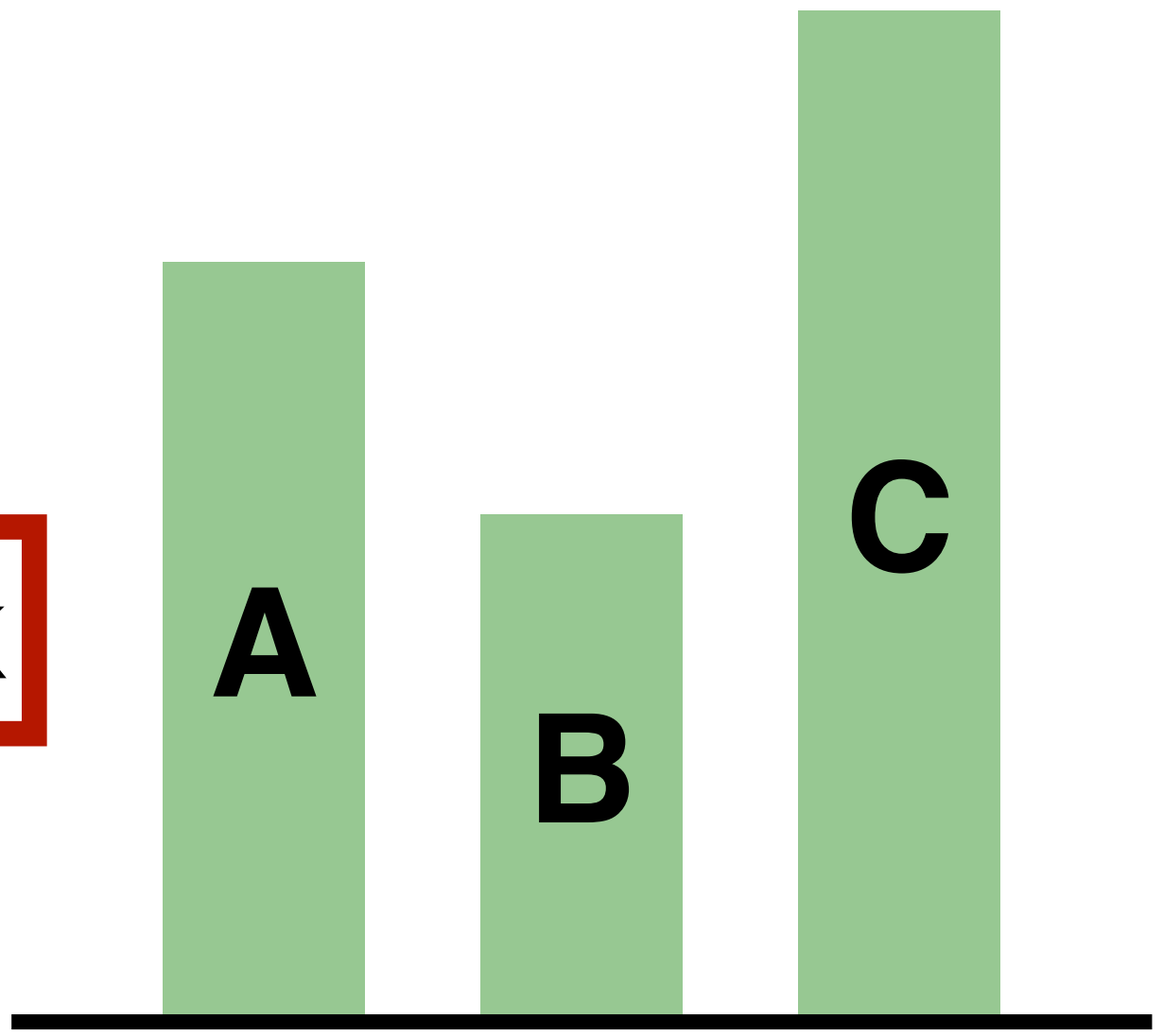
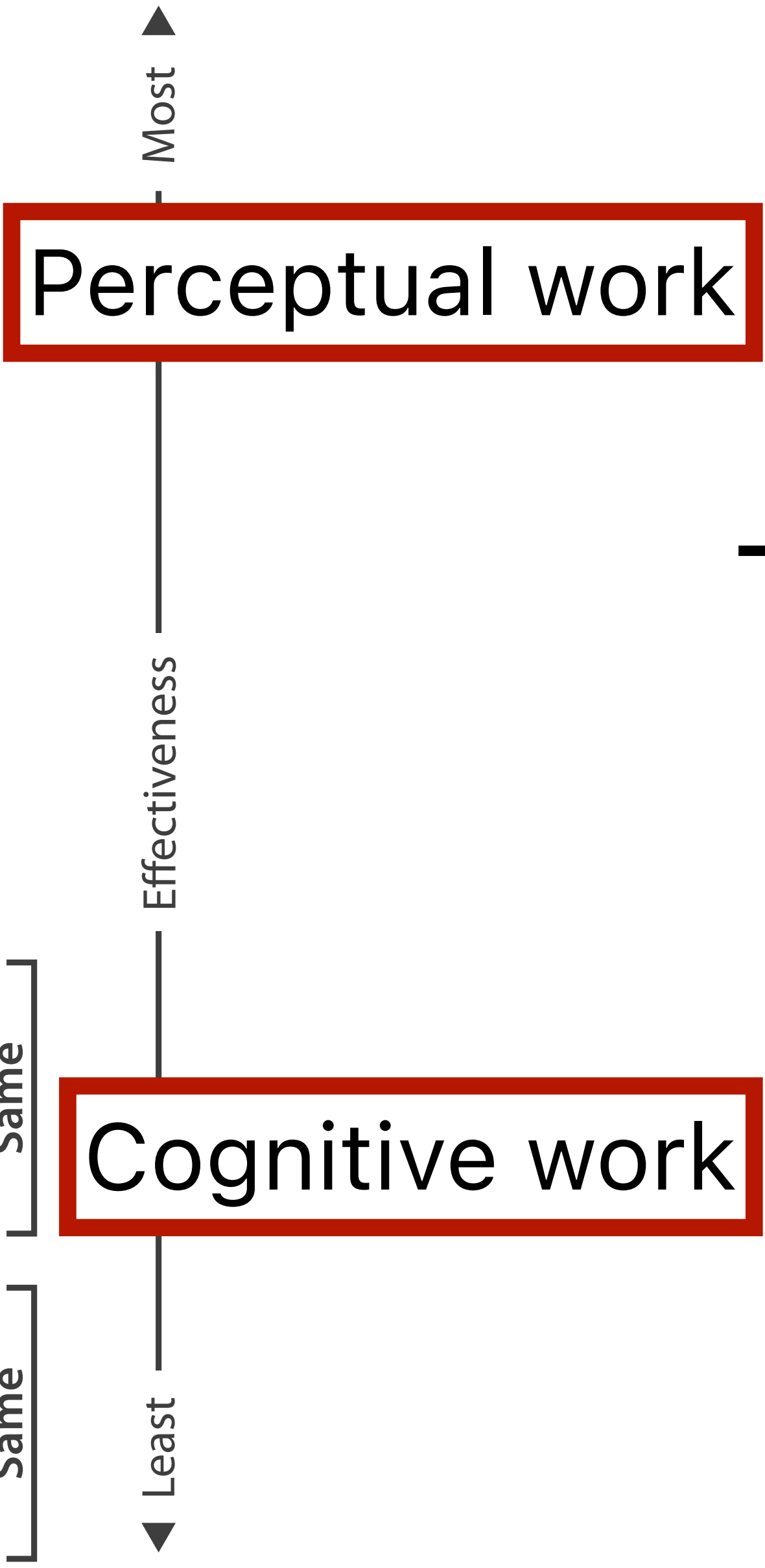
Depth (3D position) 

Color luminance 

Color saturation 

Curvature 

Volume (3D size) 



Graphical Perception

The ability of viewers to interpret visual (graphical) encodings of information and thereby decode information in graphs.

Signal Detection

Magnitude Estimation

Pre-Attentive Processing

Selective Attention

Gestalt Grouping

Signal Detection

Discriminability: how easy is it to tell two things apart?

Magnitude Estimation

Pre-Attentive Processing

Selective Attention

Gestalt Grouping

Which is brighter?

tryclassbuzz.com:
brighter1



rgb(128, 128, 128)

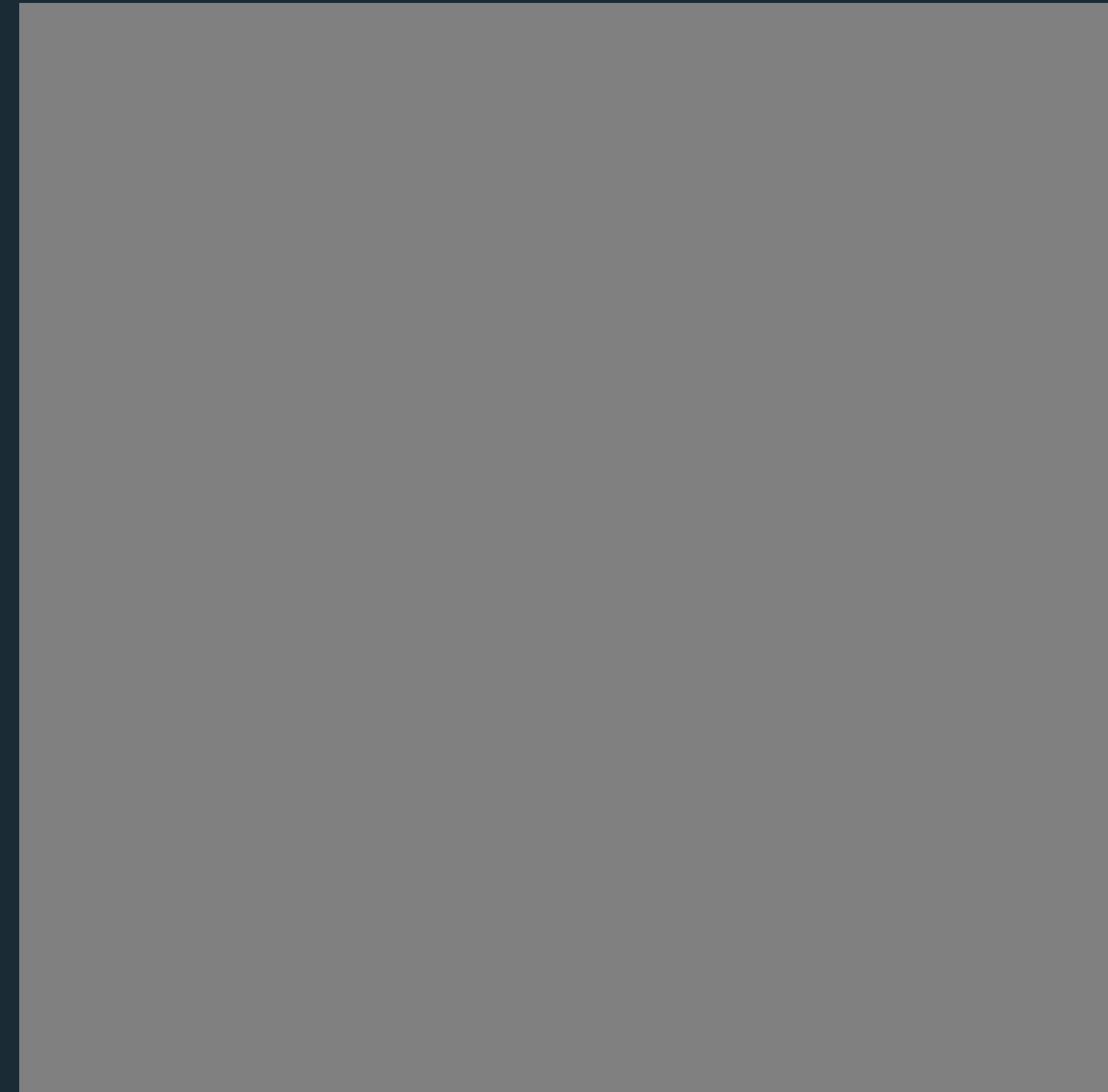


rgb(144, 144, 144)

Which is brighter?



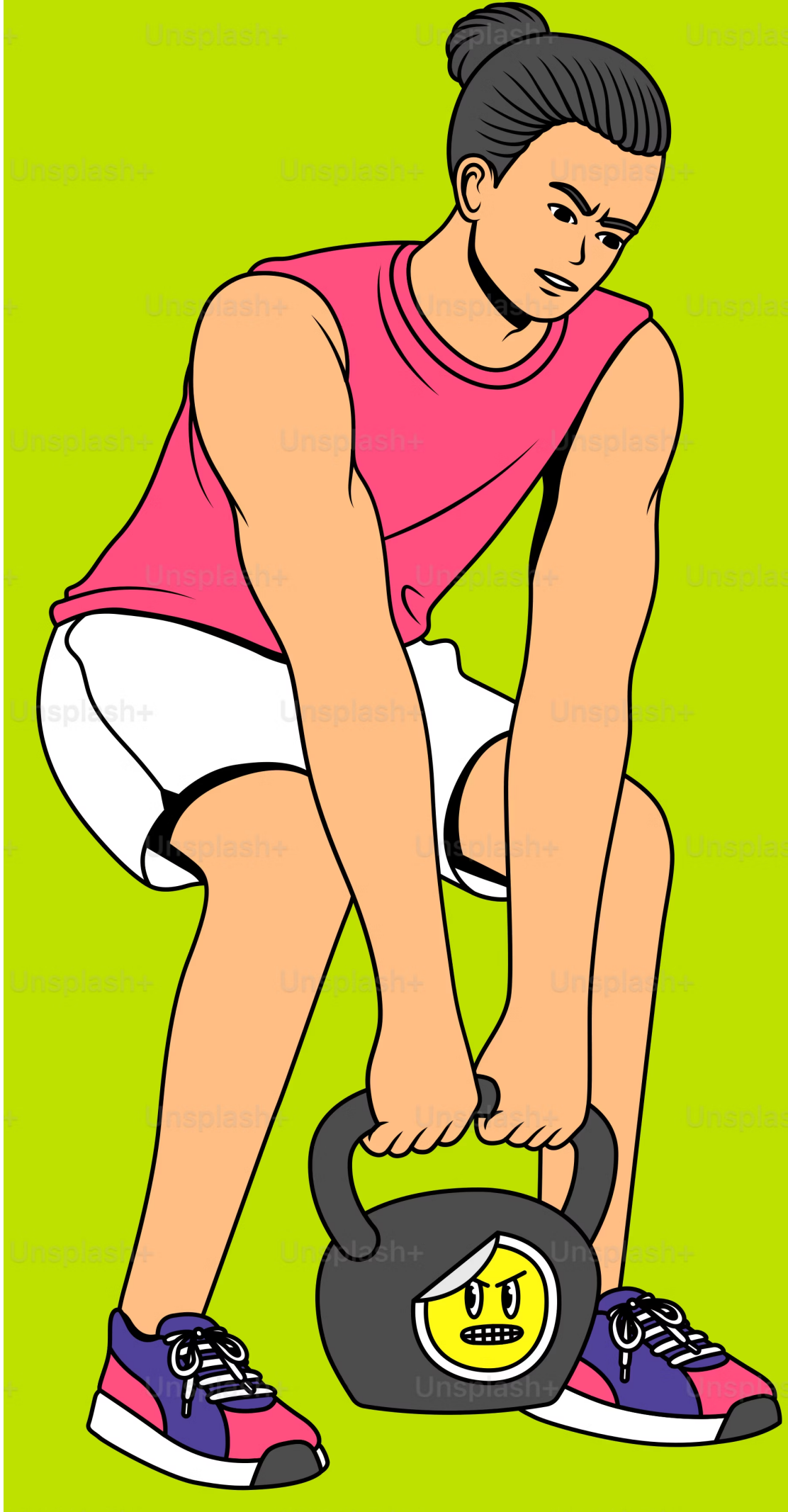
tryclassbuzz.com:
brighter2



Just Noticeable Difference (jnd)



Ernst Weber
(1795 – 1878)
German physician
and a founder of
experimental
psychology.



Start with 2kg

add 5g

Don't notice

add 20g

Notice!

Start with 5kg

add 20g

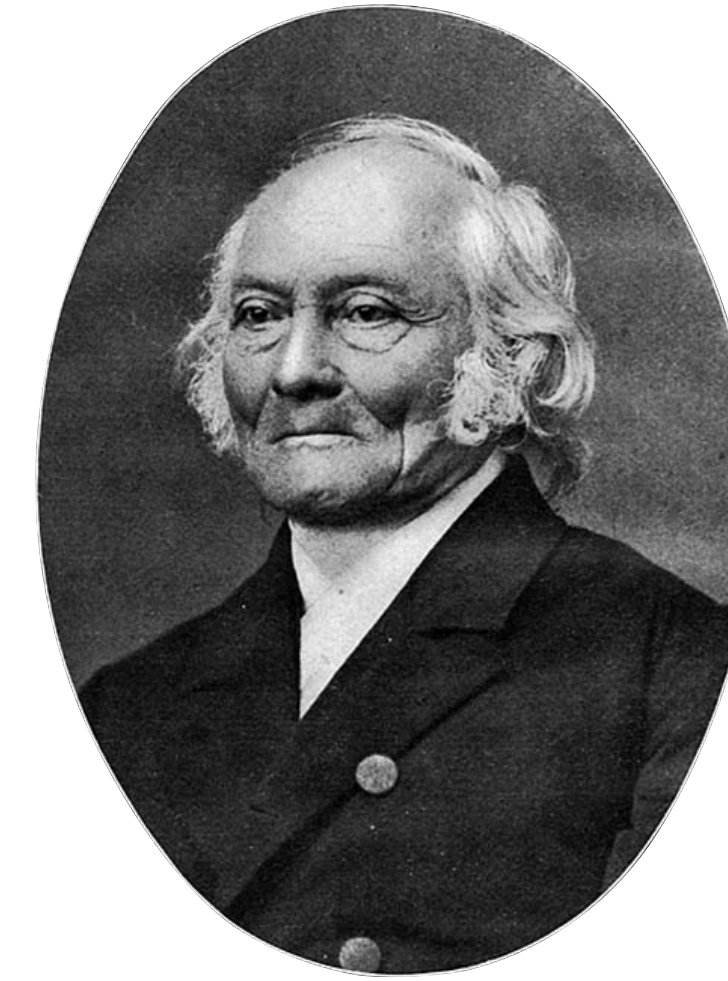
Don't notice

add 50g

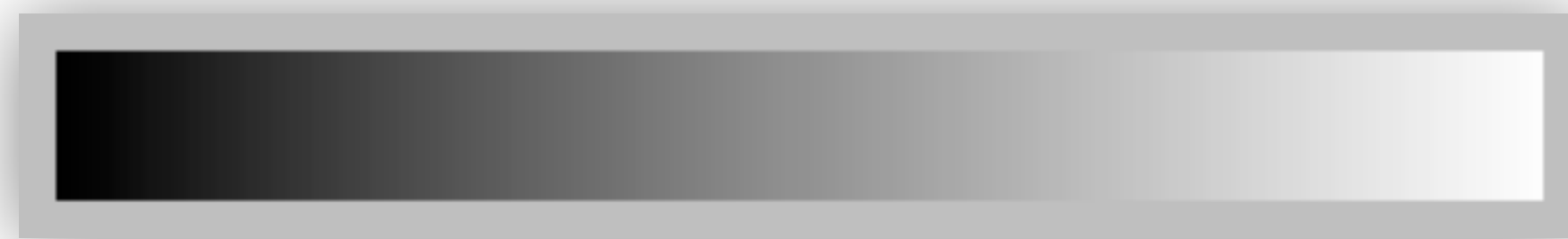
Notice!

**Jnd is proportional to
original intensity**

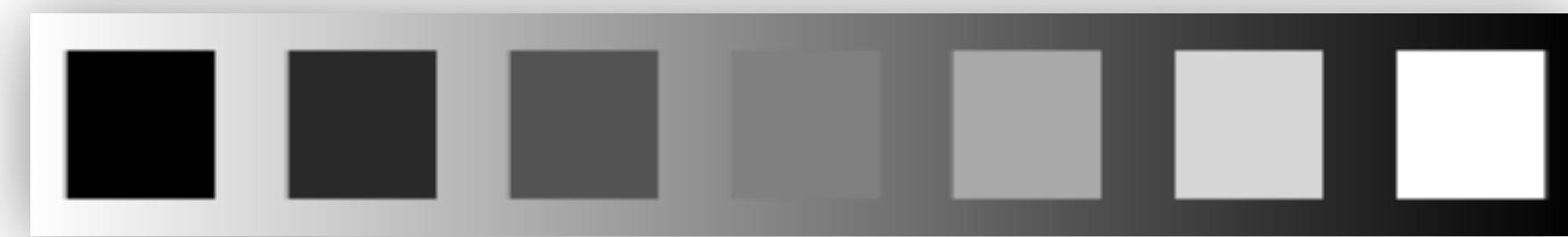
Just Noticeable Difference (jnd)



Ernst Weber
(1795 – 1878)
German physician
and a founder of
experimental
psychology.



vs.



Ratios more important than magnitude

Our brains treat continuous variations like discrete steps

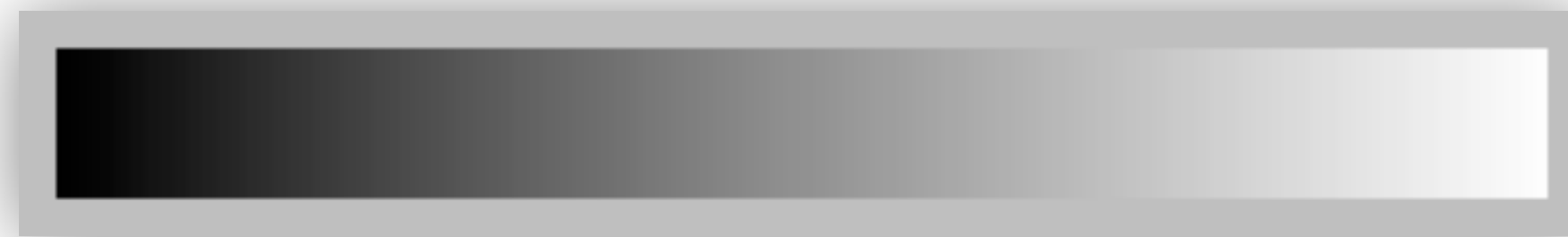
Just Noticeable Difference (jnd)



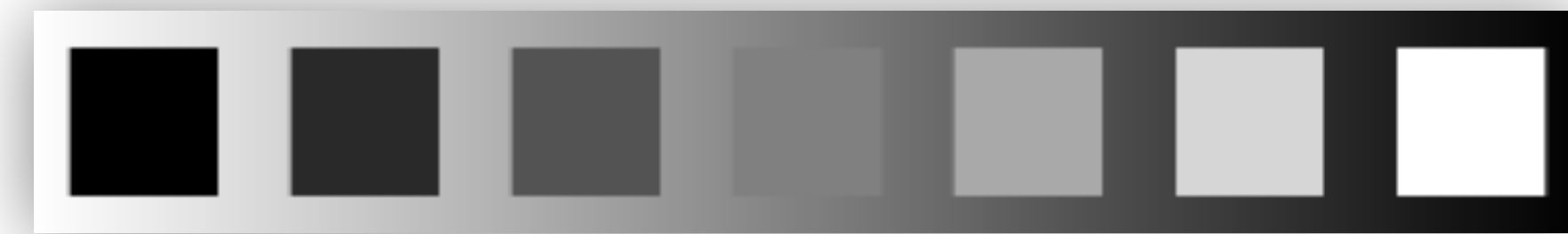
Ernst Weber
(1795 – 1878)
German physician
and a founder of
experimental
psychology.

↓ Bad

↓ Better!



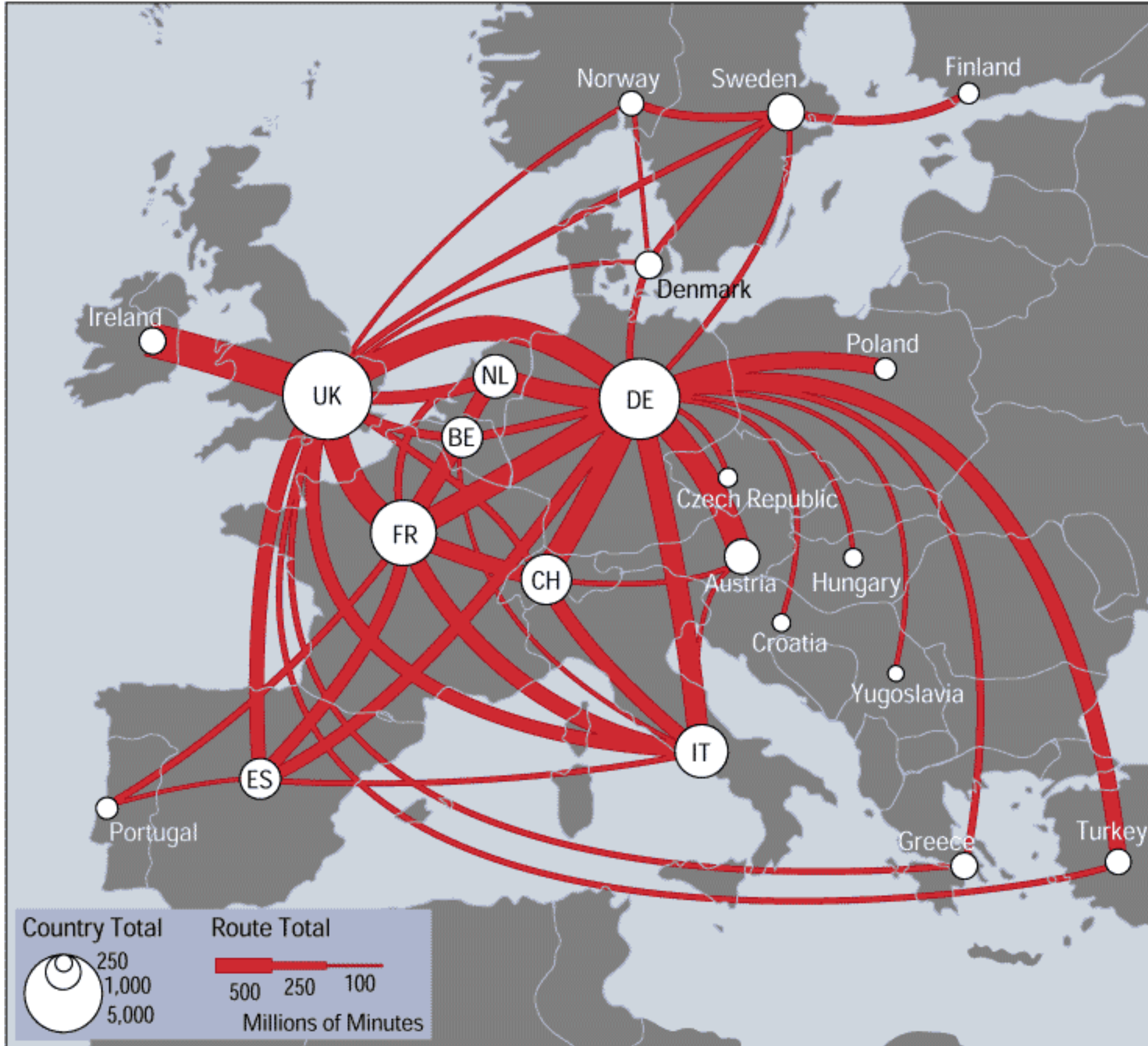
vs.



Ratios more important than magnitude

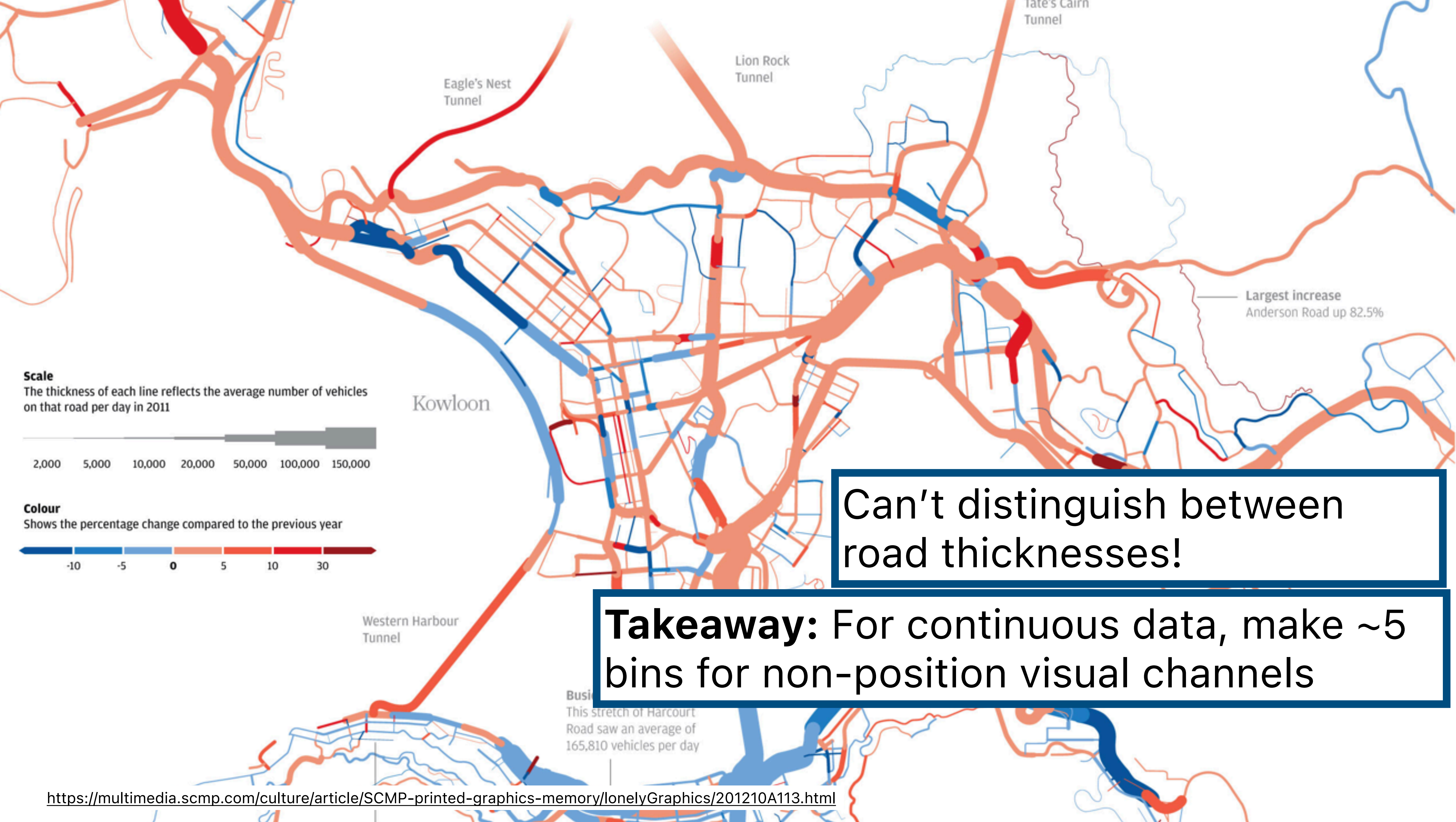
Our brains treat continuous variations like discrete steps

**We will grade you on this
for future projects!**



Jnd for line width?

Jnd for circle sizes?



Can't distinguish between road thicknesses!

Takeaway: For continuous data, make ~5 bins for non-position visual channels

Signal Detection

Discriminability: how easy is it to tell two things apart?

Magnitude Estimation

Pre-Attentive Processing

Selective Attention

Gestalt Grouping

Signal Detection

Magnitude Estimation

Accuracy: how correctly can we read off values?

Pre-Attentive Processing

Selective Attention

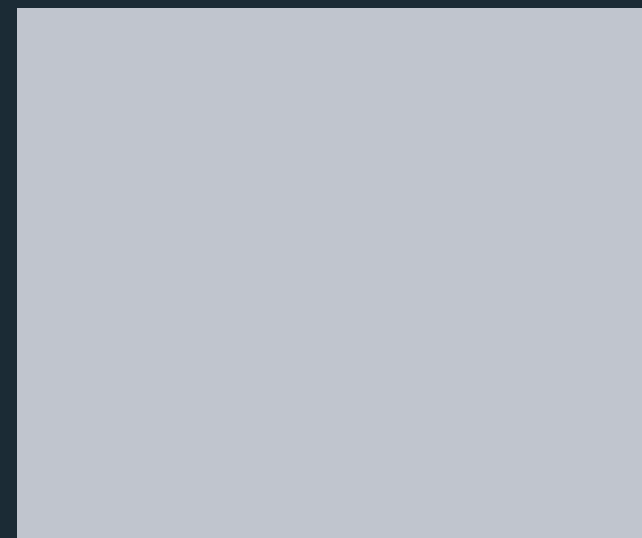
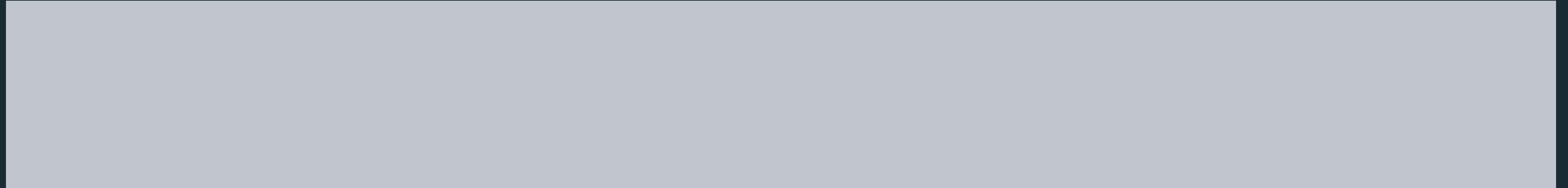
Gestalt Grouping

How much larger is the area of the big circle?



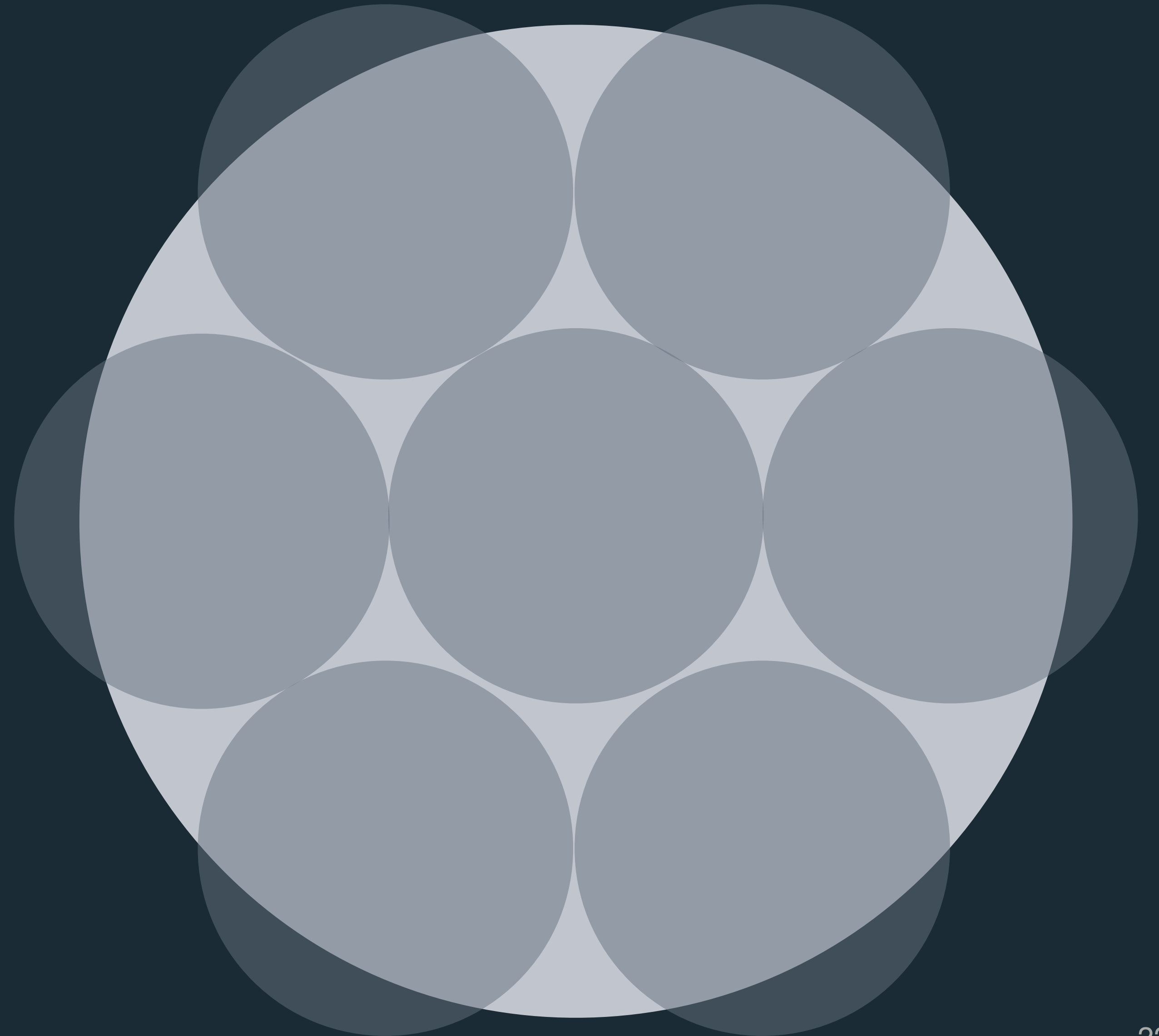
tryclassbuzz.com:
circles

How much longer is the big bar?

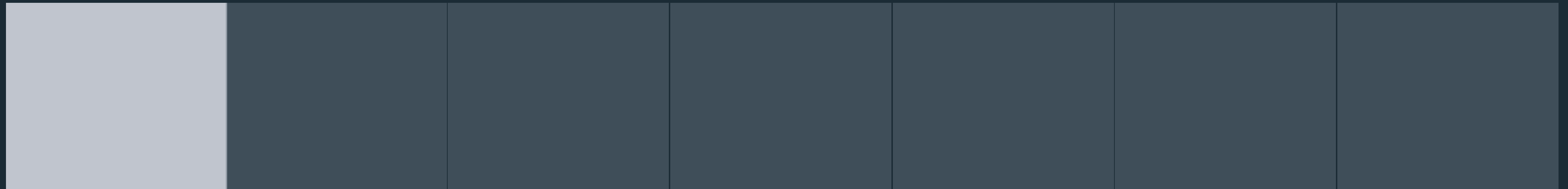
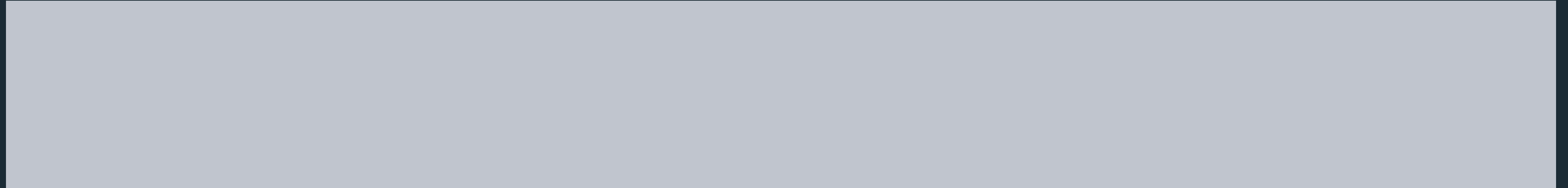


tryclassbuzz.com:
bars

How much larger is the area of the big circle?



How much longer is the big bar?



Graphical Perception Studies

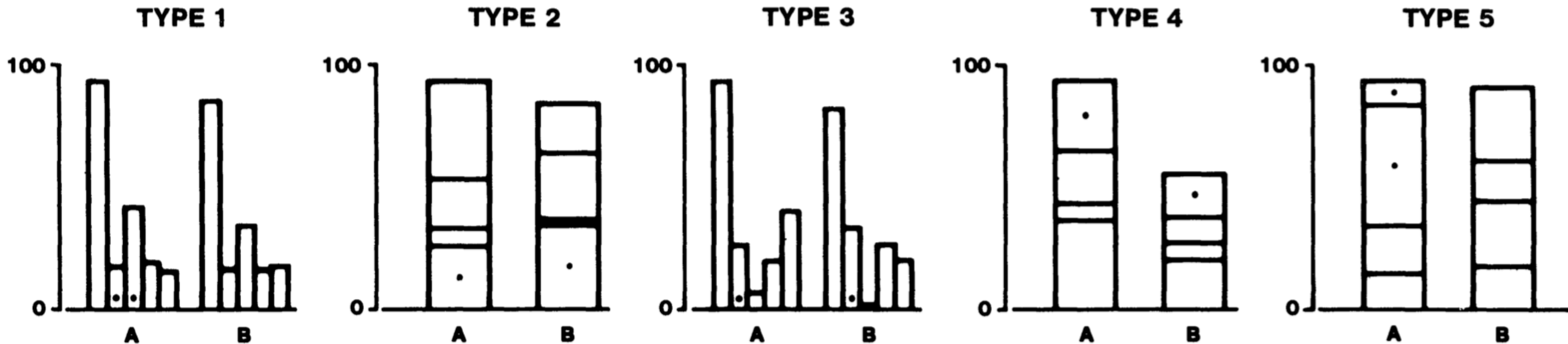


Figure 4. Graphs from position-length experiment.

What proportion is the smaller marked section of the larger?

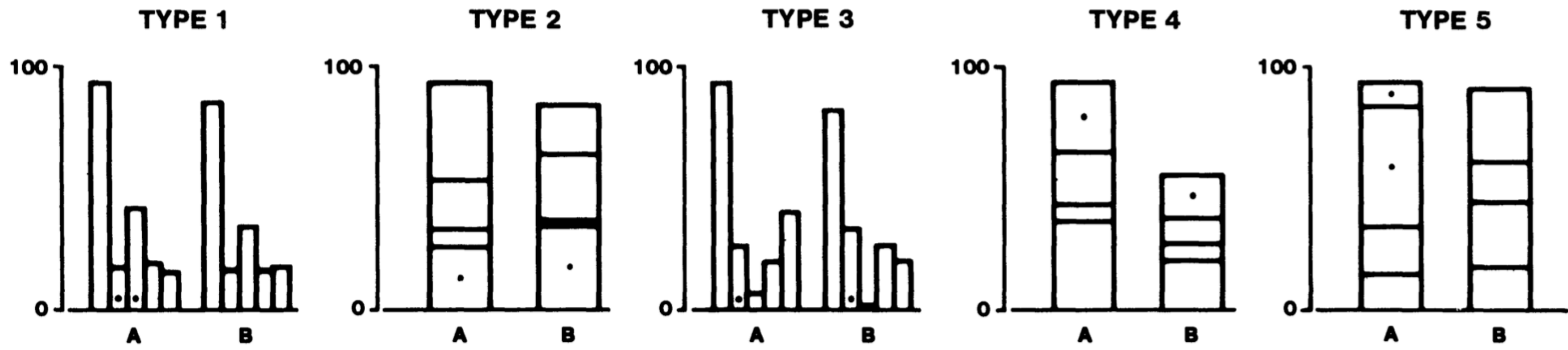
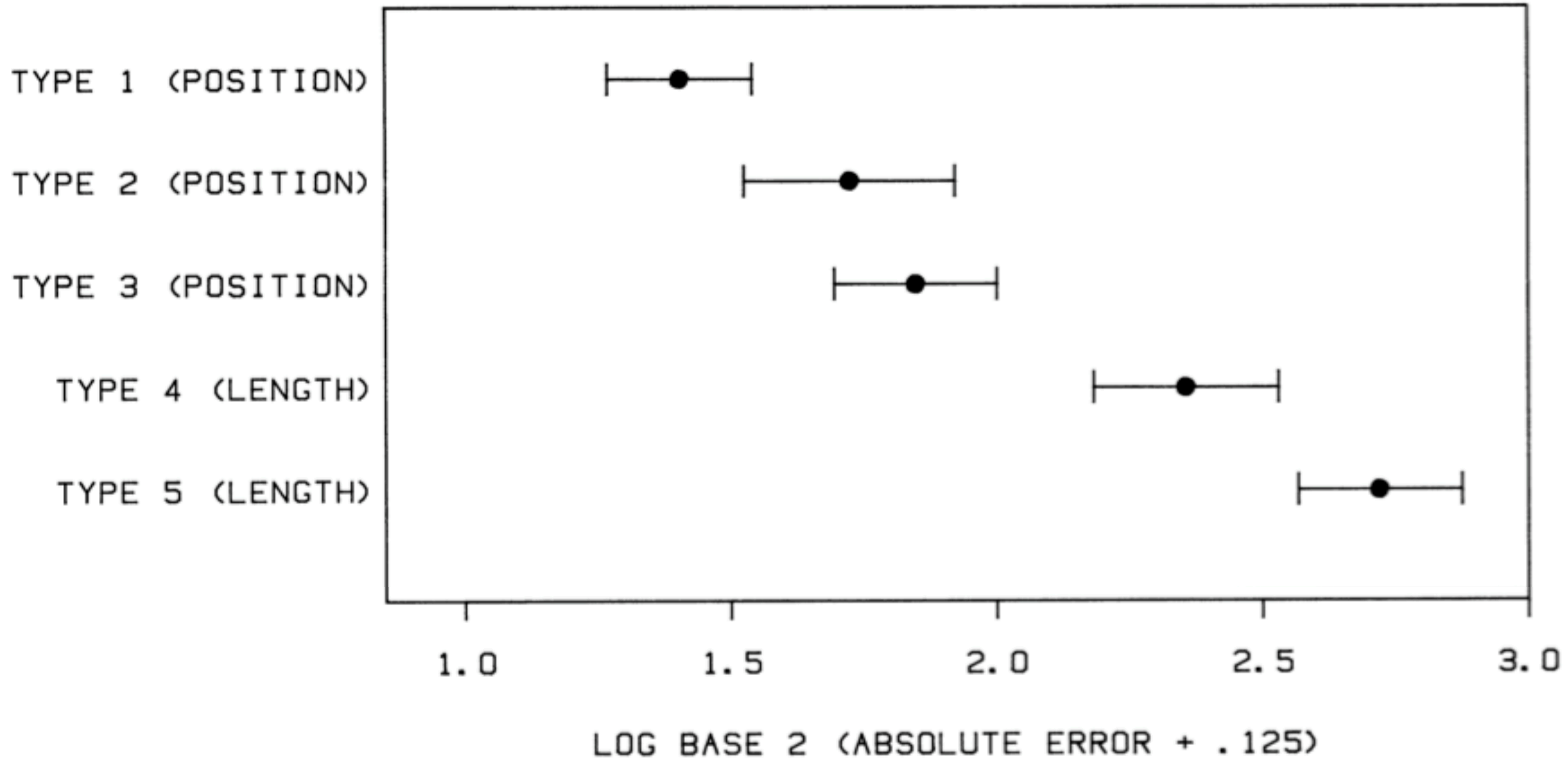
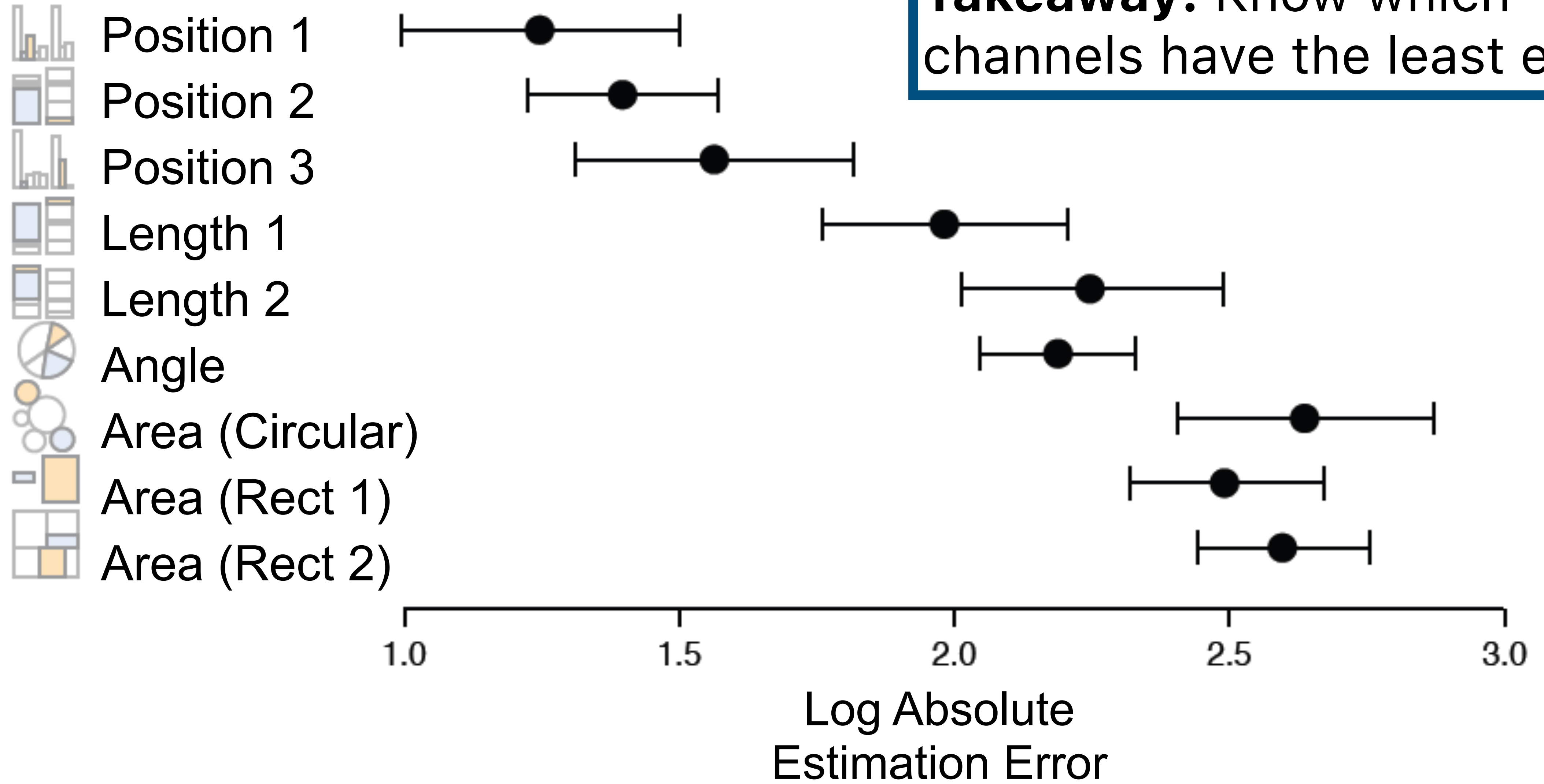


Figure 4. Graphs from position-length experiment.



Takeaway: Know which channels have the least error!



Signal Detection

Magnitude Estimation

Accuracy: how correctly can we read off values?

Pre-Attentive Processing

Selective Attention

Gestalt Grouping

Signal Detection

Magnitude Estimation

Pre-Attentive Processing

Selective Attention

Gestalt Grouping

Pop Out: how easy is it to spot some values from the rest?

How many 3s?

1281768756138976546984506985604982826762
9809858458224509856458945098450980943585
9091030209905959595772564675050678904567
8845789809821677654876364908560912949686

How many 3s?

12817687561**3**8976546984506985604982826762
980985845822450985645894509845098094**3**585
90910**3**0209905959595772564675050678904567
8845789809821677654876**3**64908560912949686

Pre-Attentive Processing

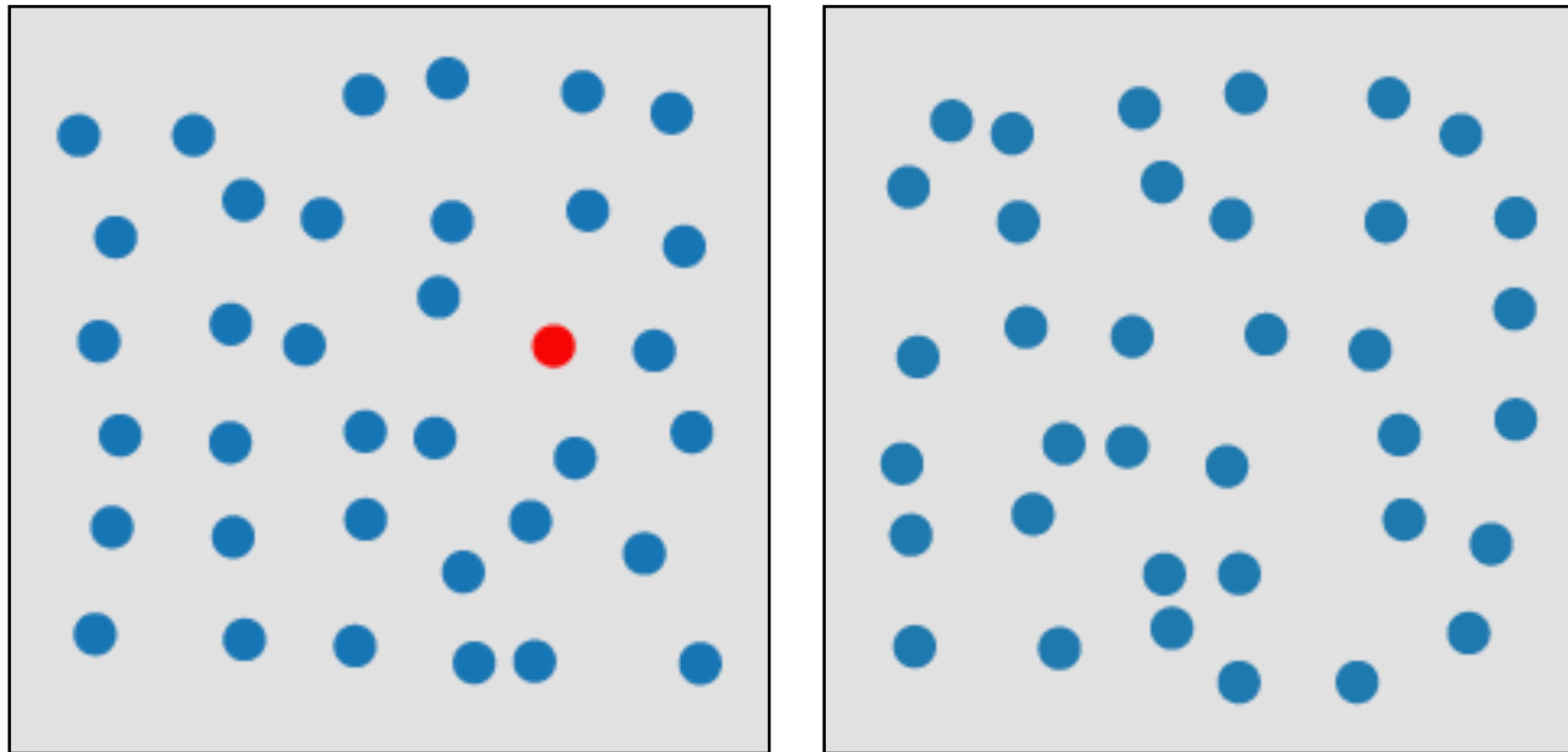
How fast does our visual system perceive differences?

Pre-Attentive: immediately recognize variation with little or no conscious effort (<200–250 ms).

Attentive: Takes some deliberate effort to perceive differences.

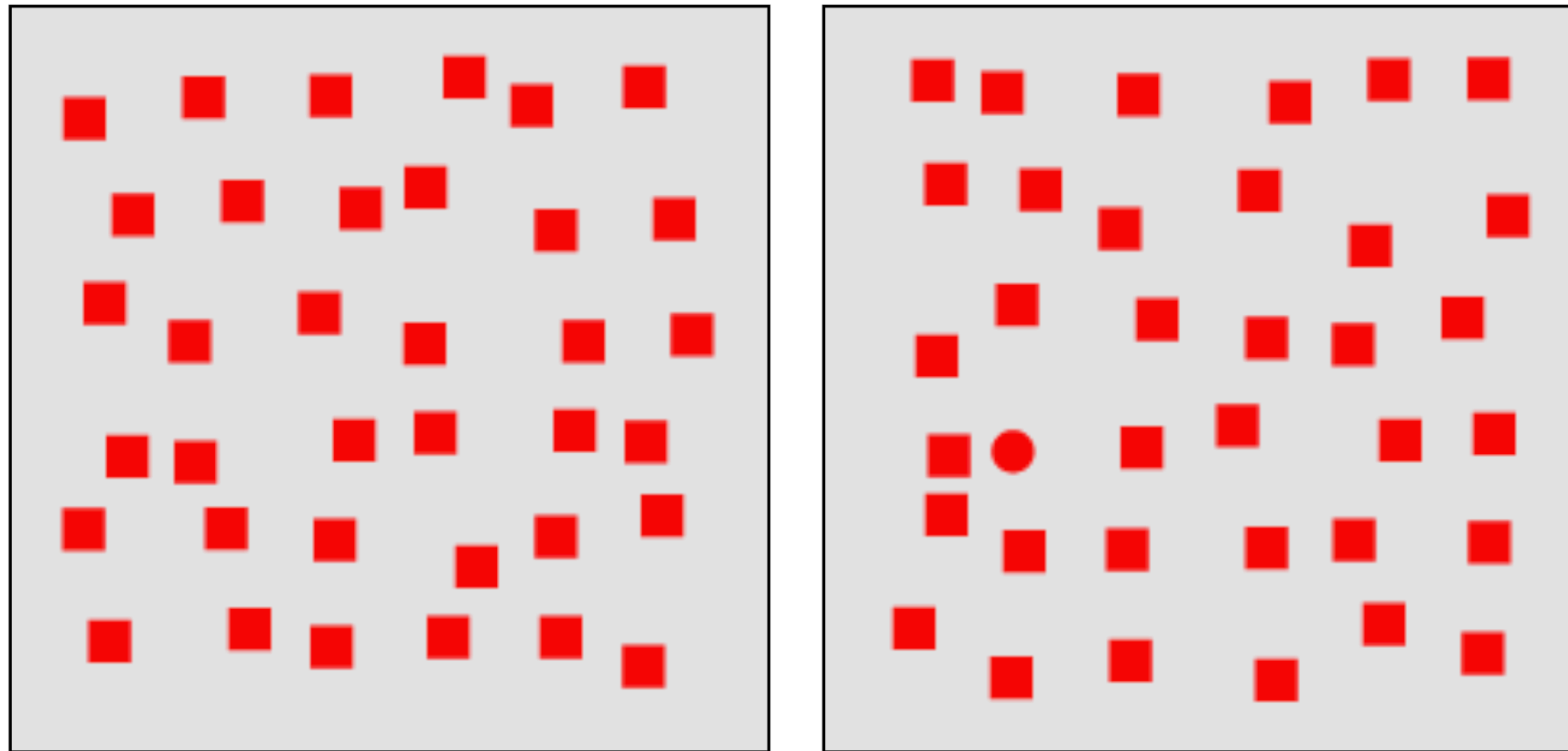
Pre-Attentive Processing

Color is pre-attentive



Pre-Attentive Processing

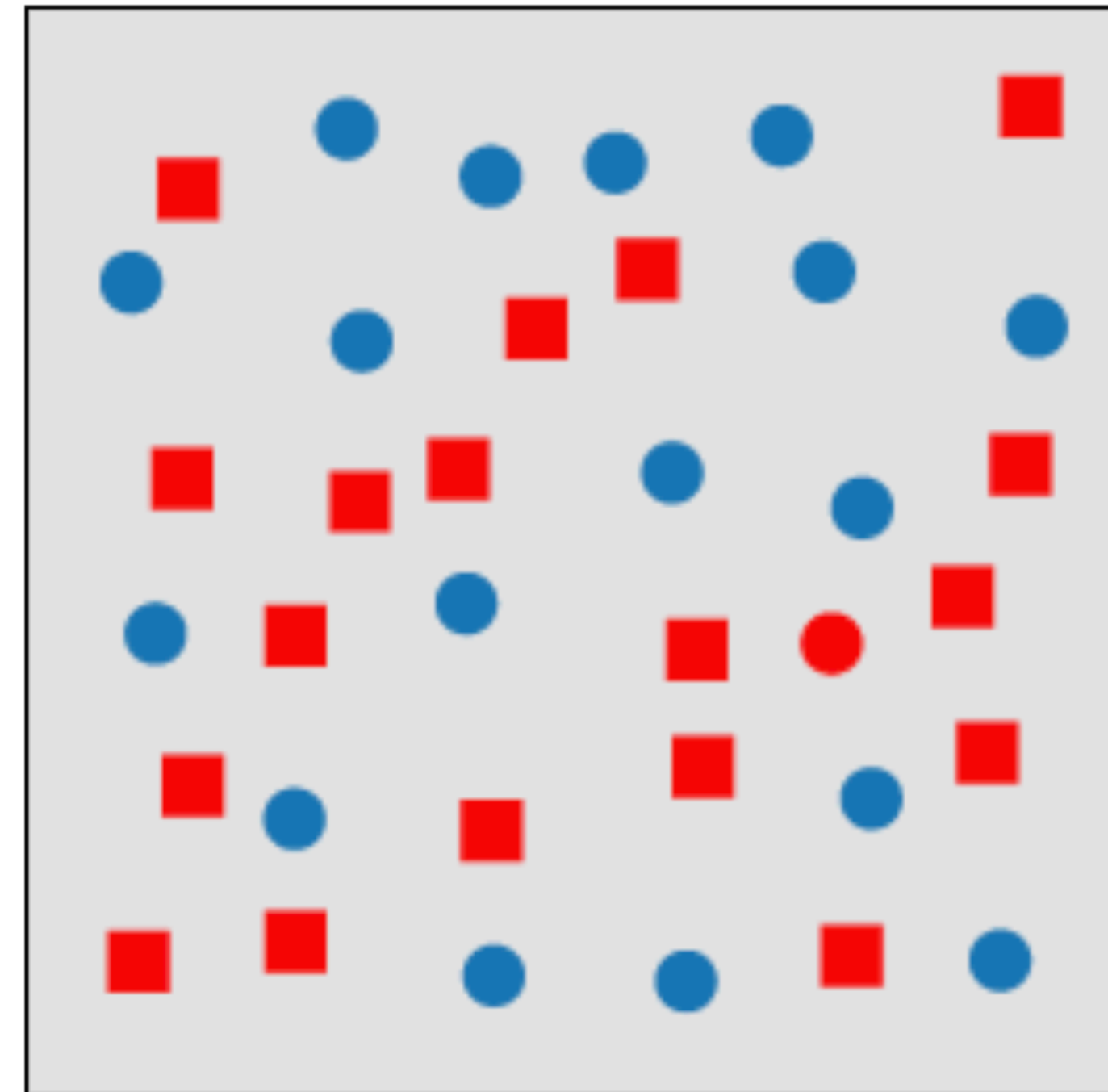
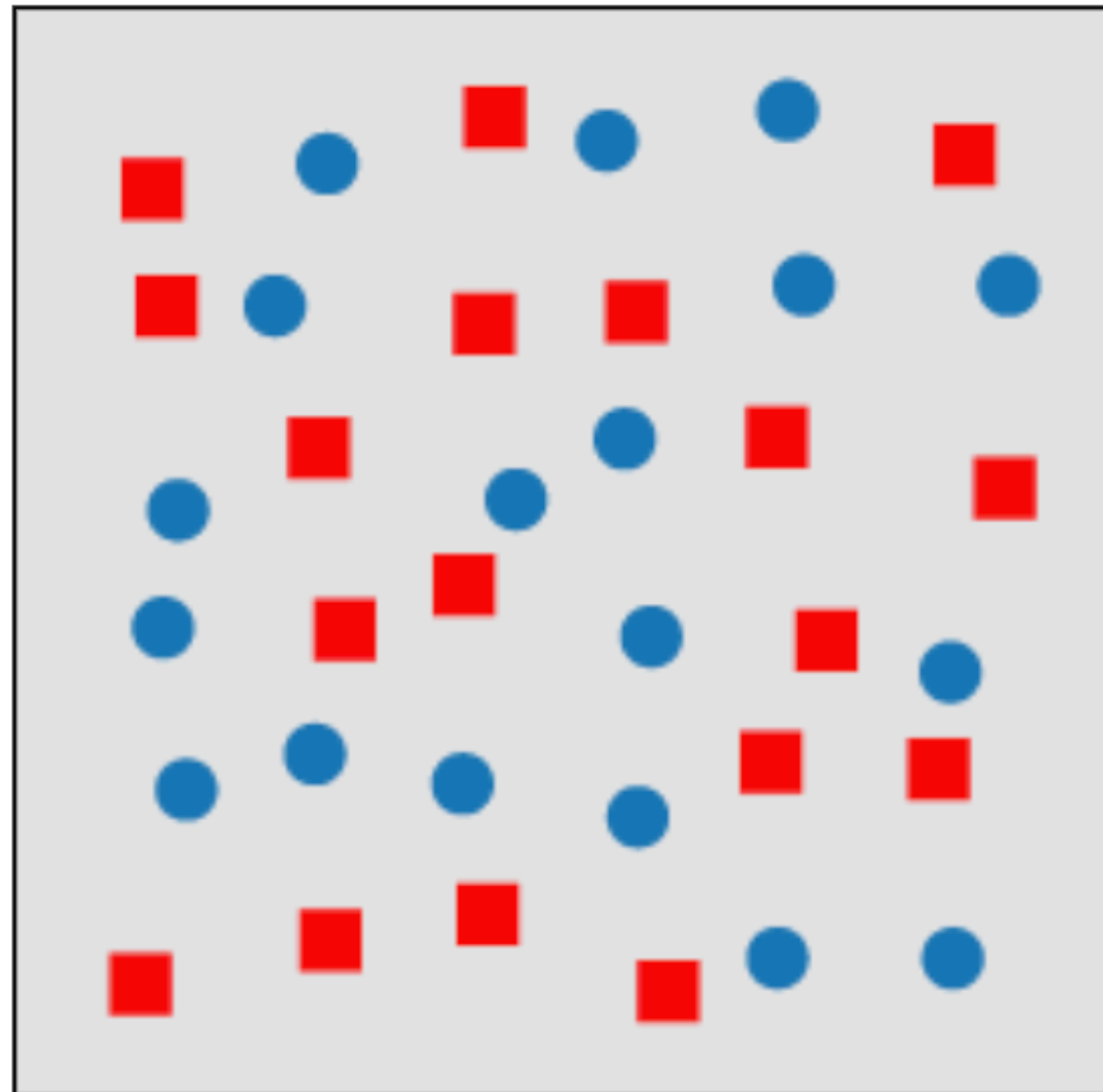
Shape too



Pre-Attentive Processing

But not a conjunction!

A *conjunction* is a combination of 2+ visual features.



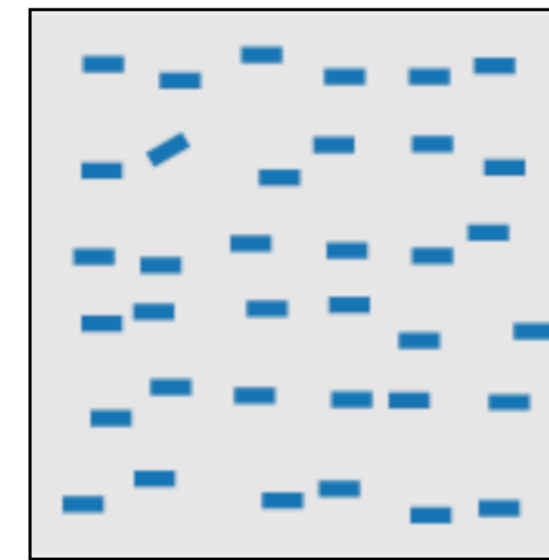
Pre-Attentive Processing

A few more pre-attentive features:

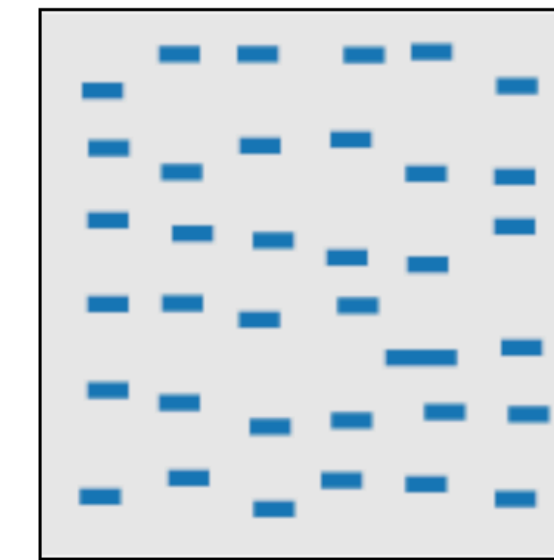
Many spatial features are pre-attentive

Many spatial *conjunctions* are also pre-attentive

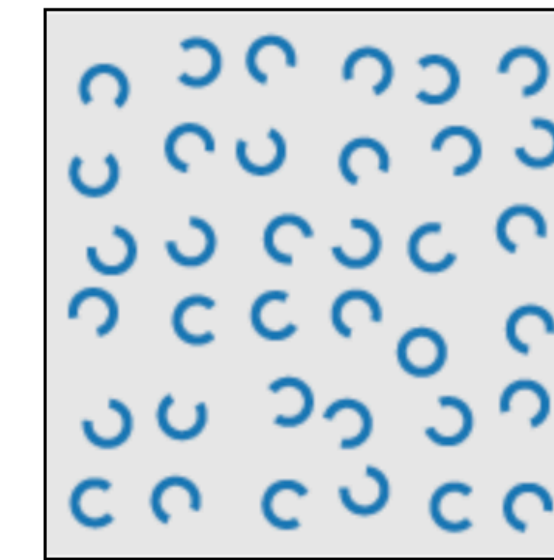
But most other conjunctions are **NOT pre-attentive**



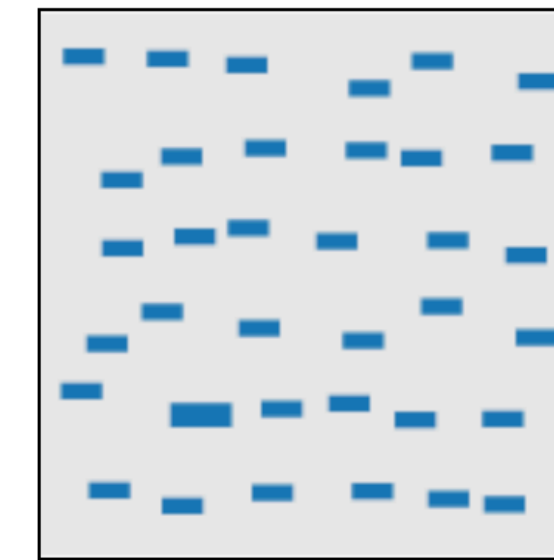
line (blob) orientation
Júlész & Bergen 83; Sagi & Júlész 85a, Wolfe et al. 92; Weigle et al. 2000



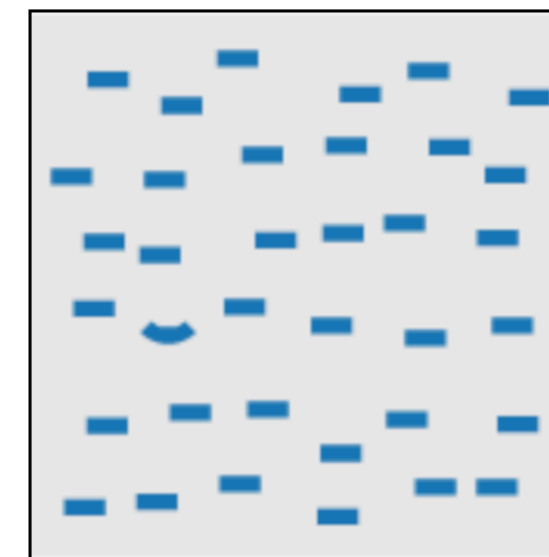
length, width
Sagi & Júlész 85b; Treisman & Gormican 88



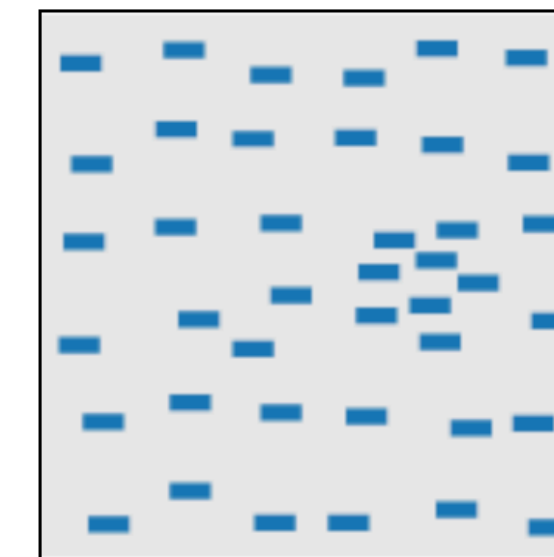
closure
Júlész & Bergen 83



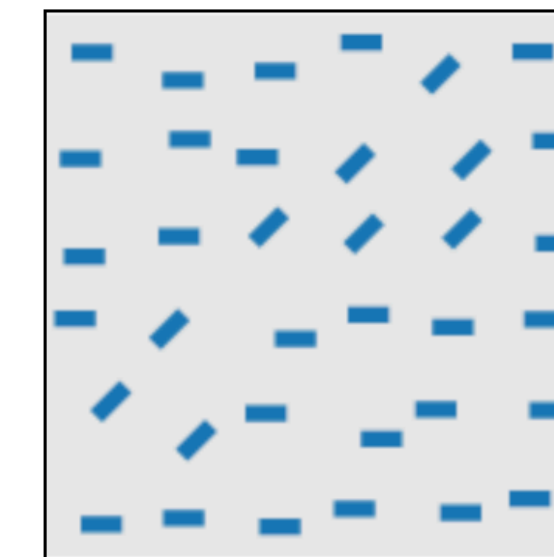
size
Treisman & Gelade 80; Healey & Enns 98; Healey & Enns 99



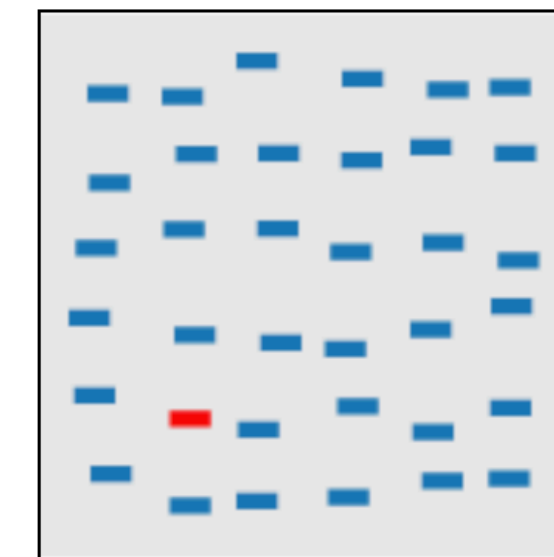
curvature
Treisman & Gormican 88



density, contrast
Healey & Enns 98; Healey & Enns 99



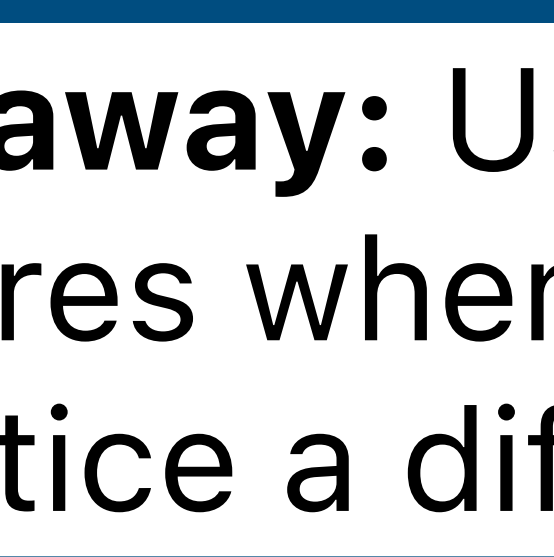
number, estimation
Sagi & Júlész 85b; Healey et al. 93; Trick & Pylyshyn 94



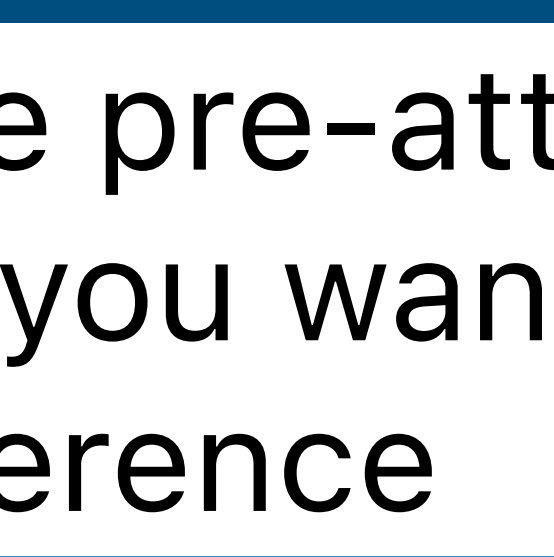
colour (hue)
Nagy & Sanchez 90; Nagy et al. 90; D'Zmura 91; Kawai et al. 95; Bauer et al. 96; Healey 96; Bauer et al. 98; Healey & Enns 99



intensity, binocular lustre
Beck et al. 83; Treisman & Gormican 88; Wolfe & Franzel 88



intersection
Júlész & Bergen 83



terminators
Júlész & Bergen 83



3D depth cues
Enns 90b; Nakayama & Silverman 86

Takeaway: Use pre-attentive features when you want reader to notice a difference

Signal Detection

Magnitude Estimation

Pre-Attentive Processing

Selective Attention

Gestalt Grouping

Pop Out: how easy is it to spot some values from the rest?

Signal Detection

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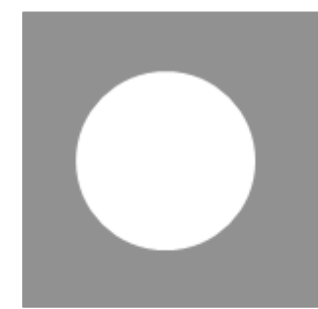
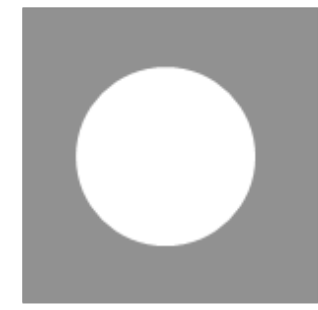

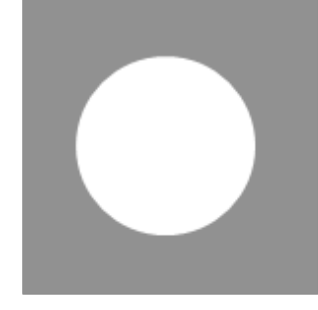

Separability: how much interaction occurs between attributes?






One-dimensional: brightness



Name the color



-  White
-  White
-  Black
-  White
-  Black

-  White
-  Black
-  Black
-  White
-  White

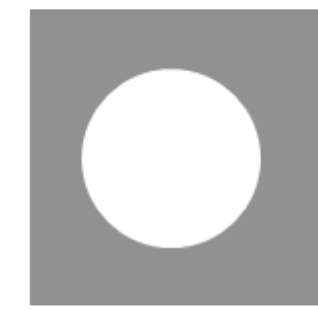
One-dimensional: shape



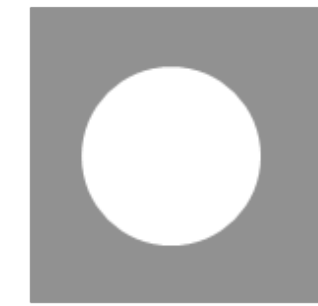
Name the shape



Square



Circle



Circle



Square



Circle



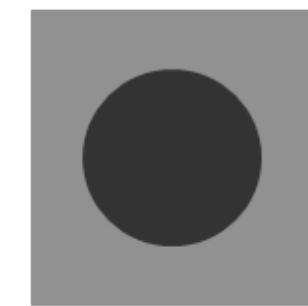
Circle



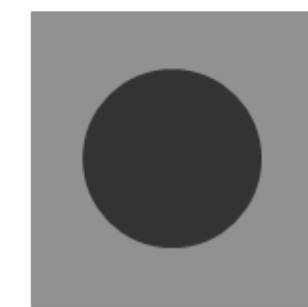
Circle



Square



Circle

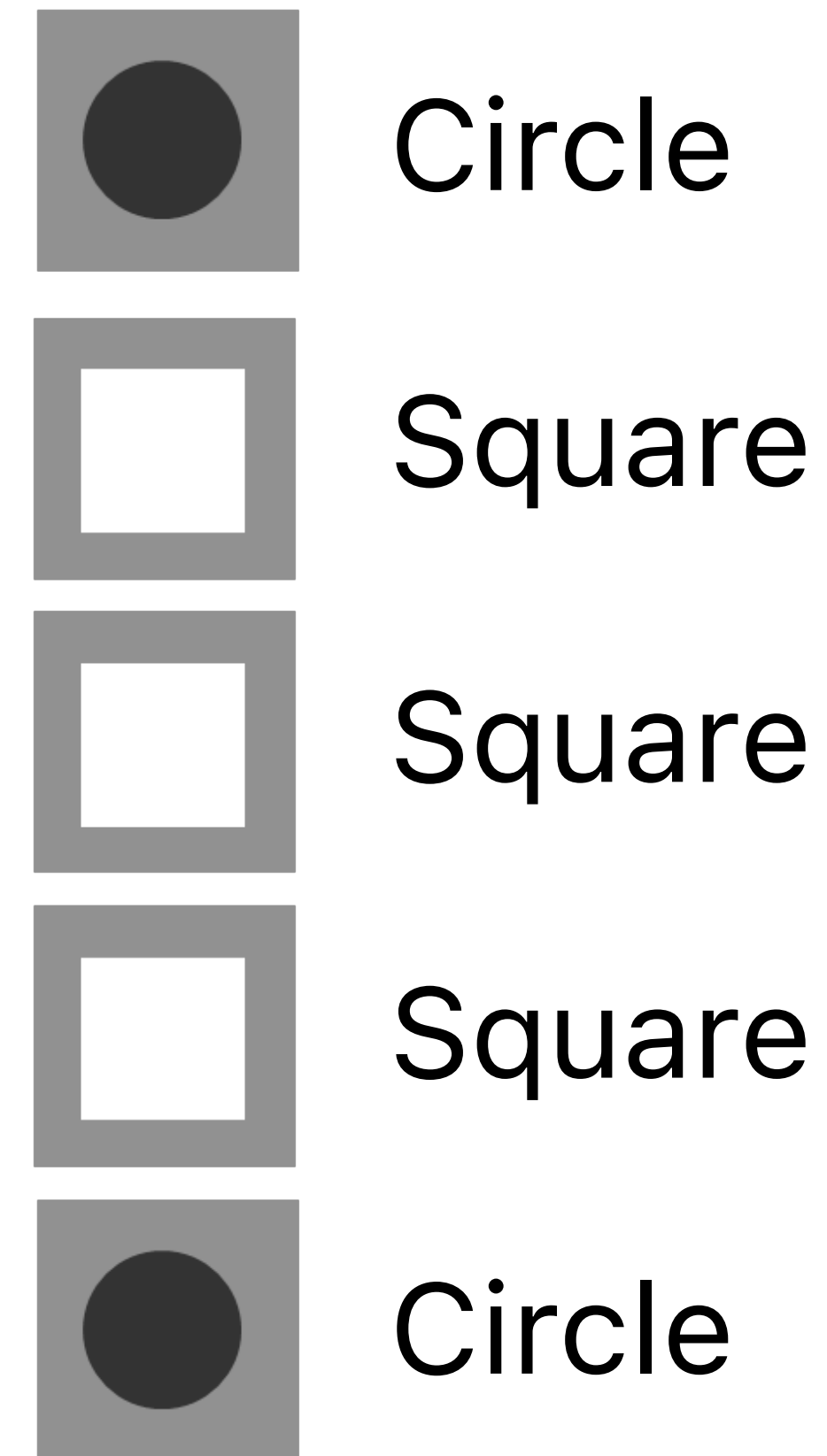
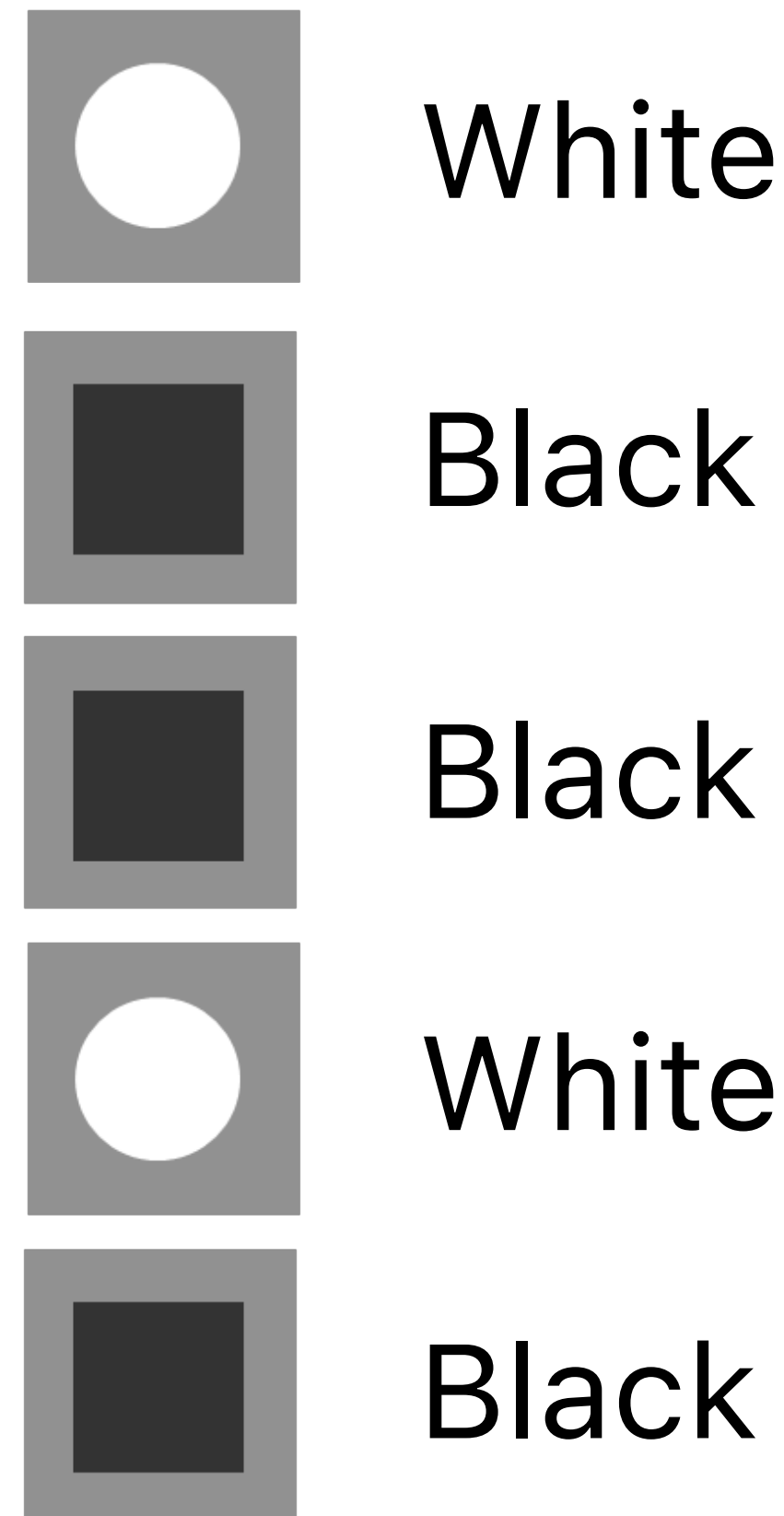


Circle

Redundant: brightness and shape



Same information in 2+ visual channels



Orthogonal: brightness and shape



Different information in 2+ visual channels

Name the color

Name the shape



White



Circle

Black



Square

White



Square

Black



Circle

White



Square

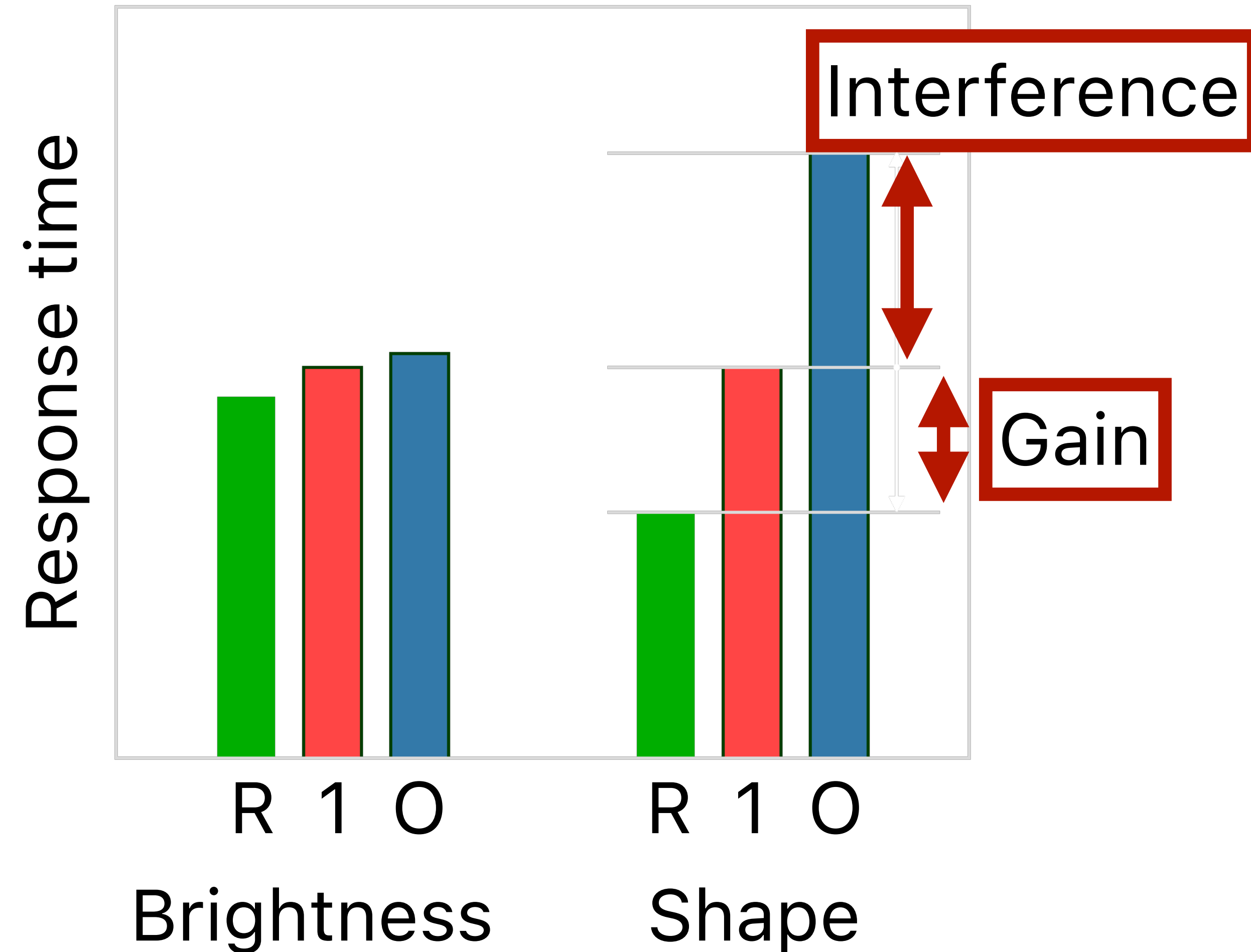
Conjunction principles

Redundancy Gain

Improved performance when both dimensions provide the same information.

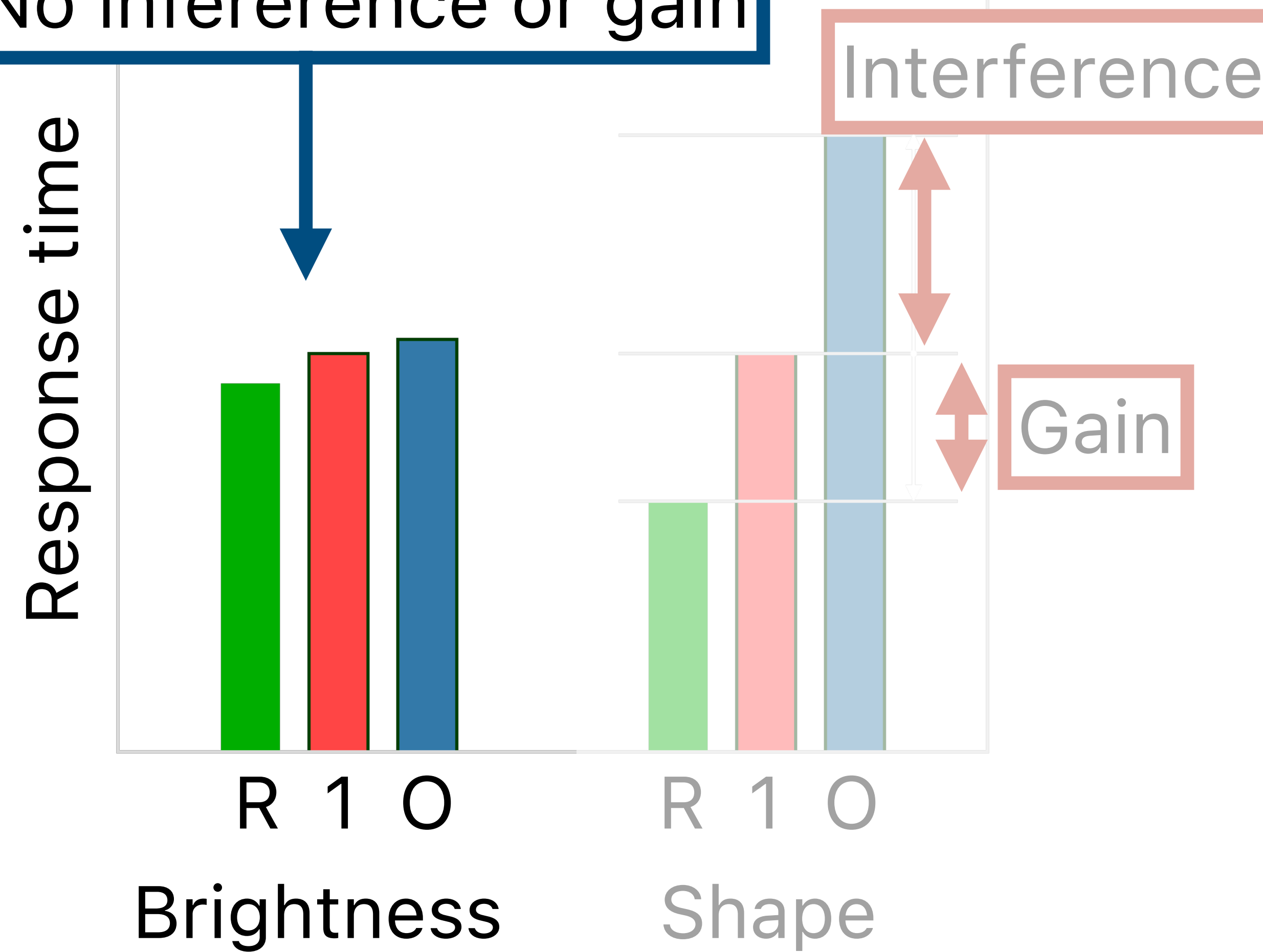
Filtering Interference

Difficulty in ignoring one dimension while attending to another.



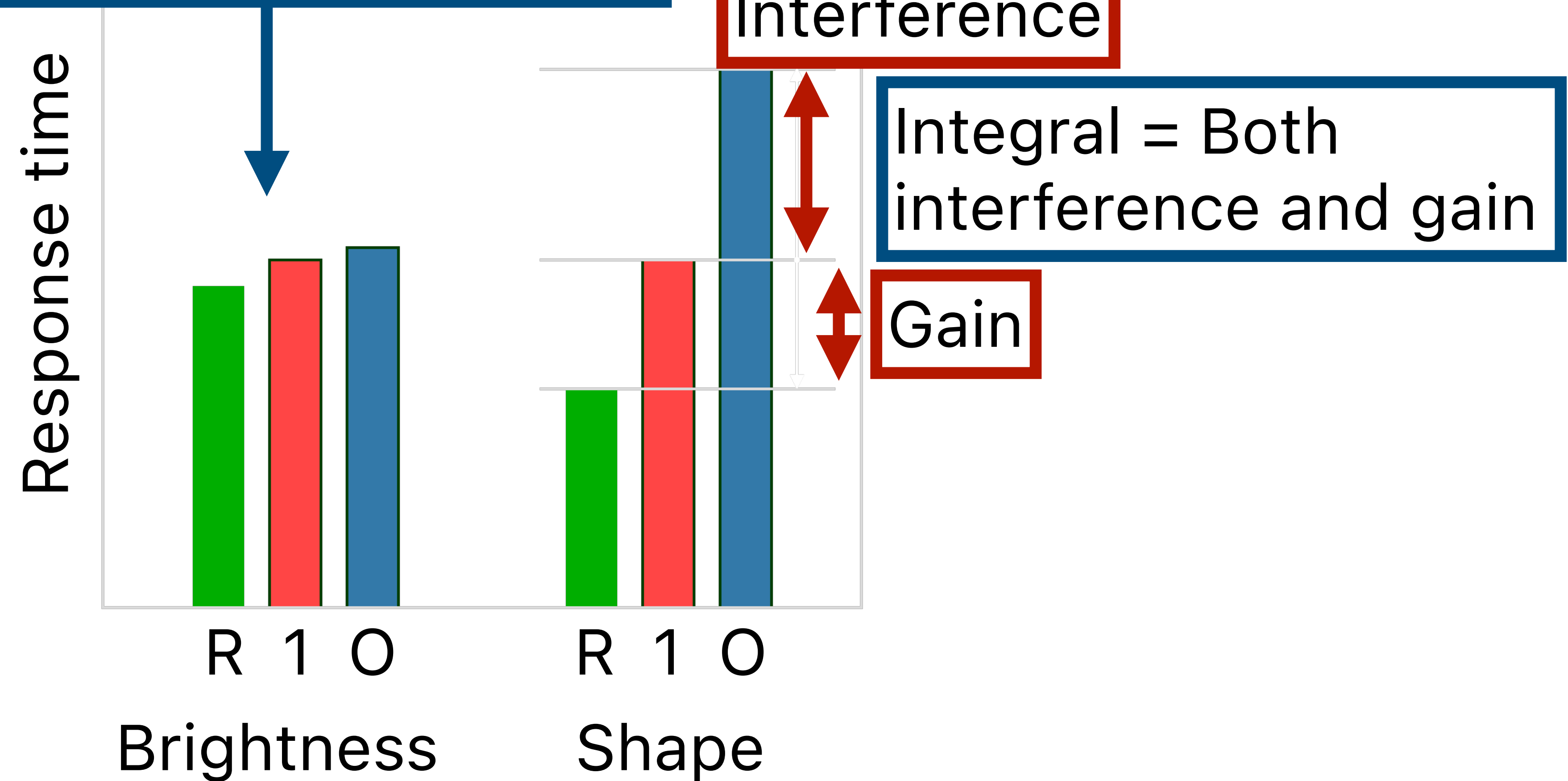
Conjunction principles

Separable = No interference or gain



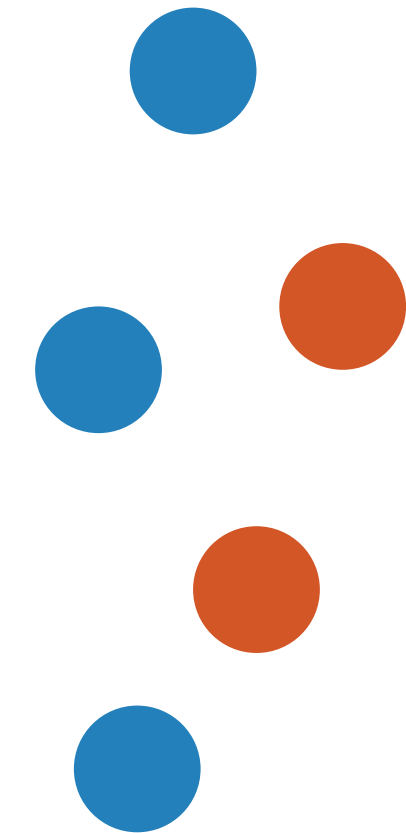
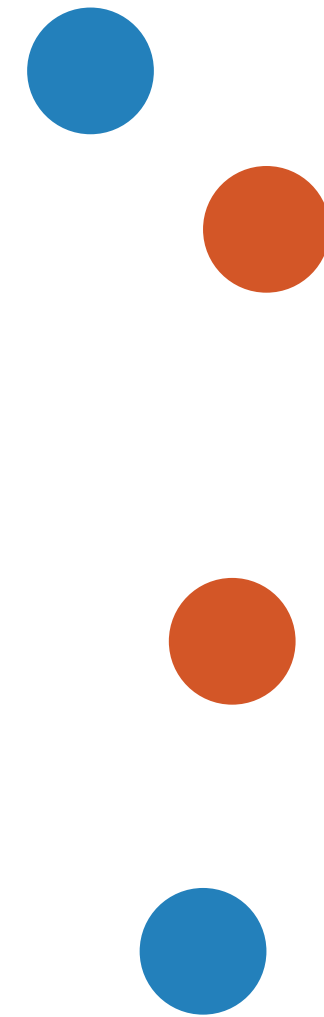
Conjunction principles

Separable = No interference or gain



Example: Position and Hue

Separable:
No interference or gain



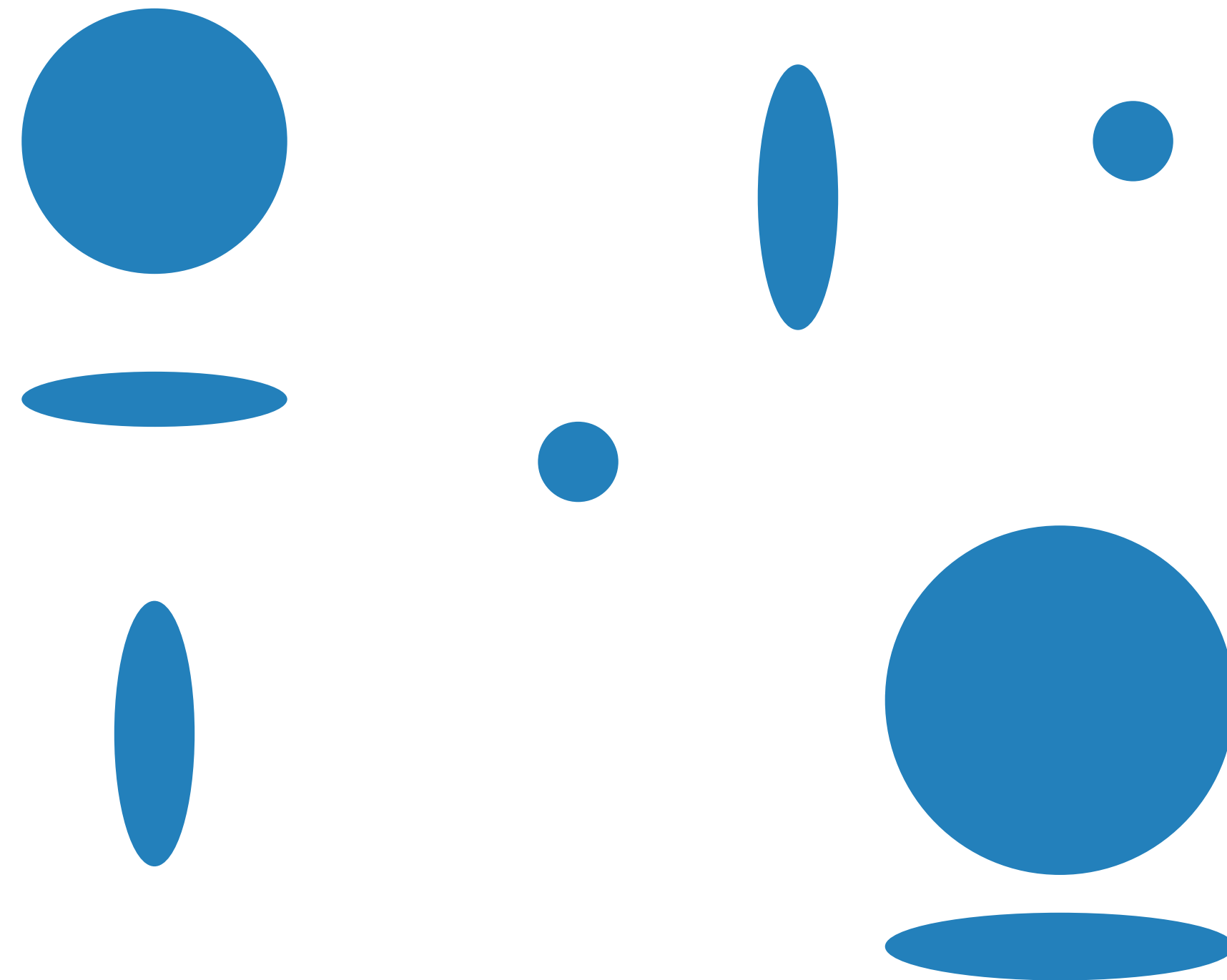
Example: Width and Height

Separable:

No interference or gain

Integral:

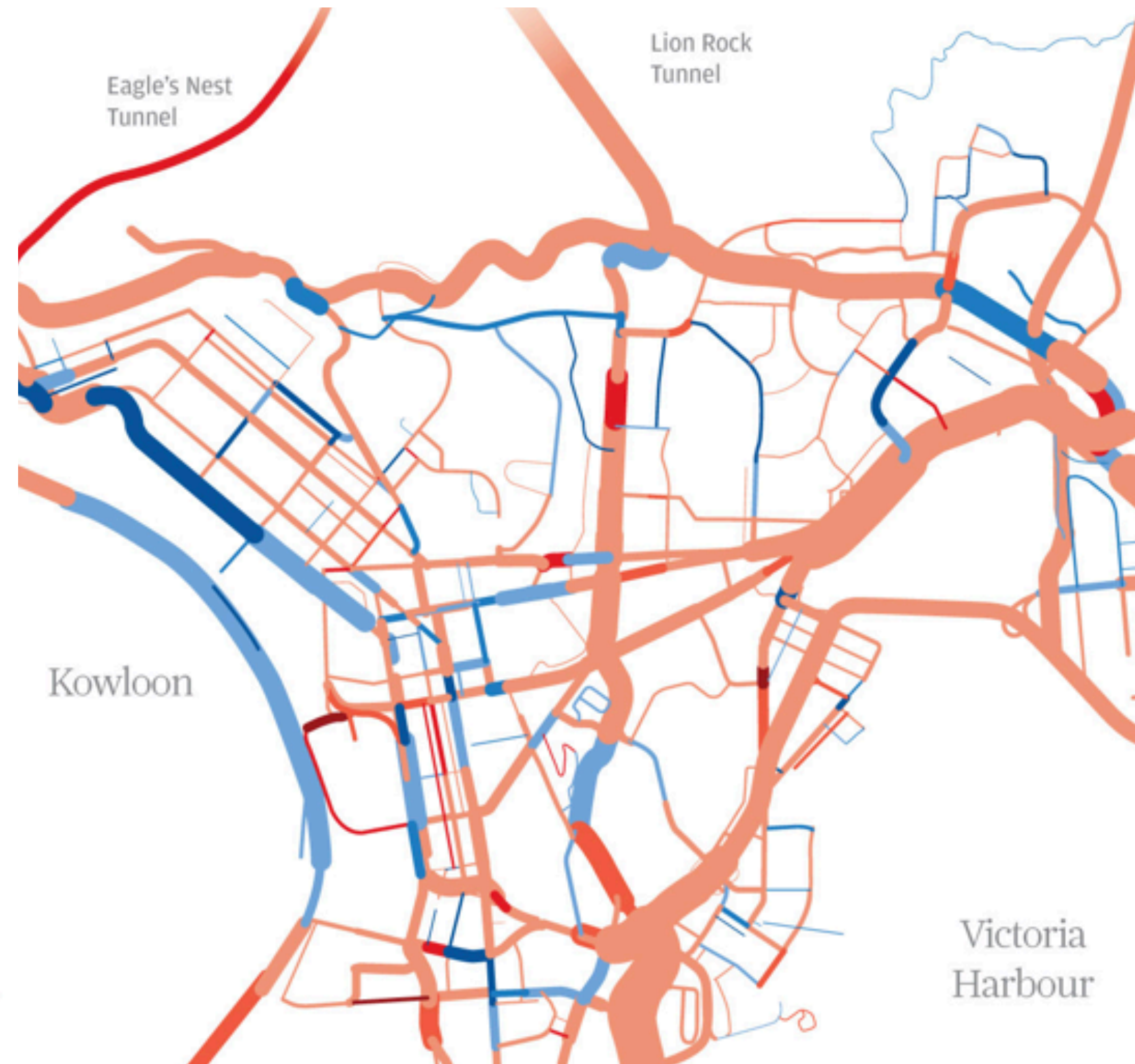
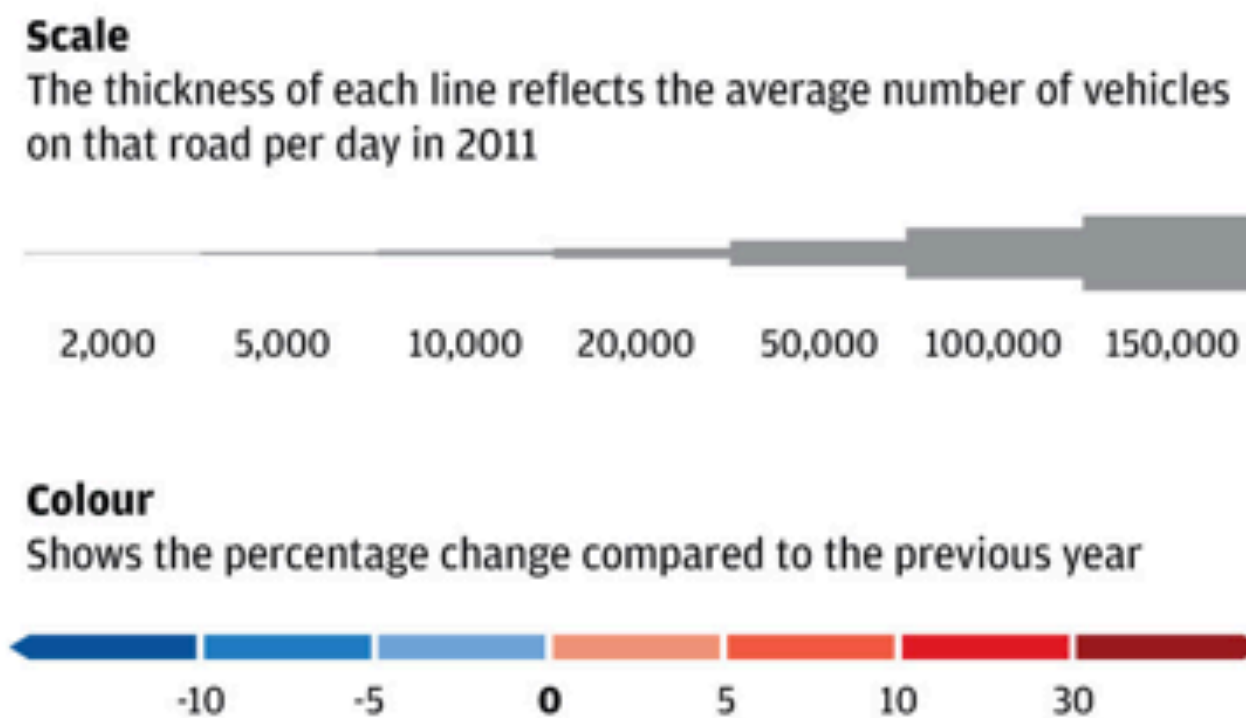
Both interference and gain



Example: Thickness and color

Separable:
No interference or gain

Integral:
Both interference and gain



Example: Shape and Size?

Separable:

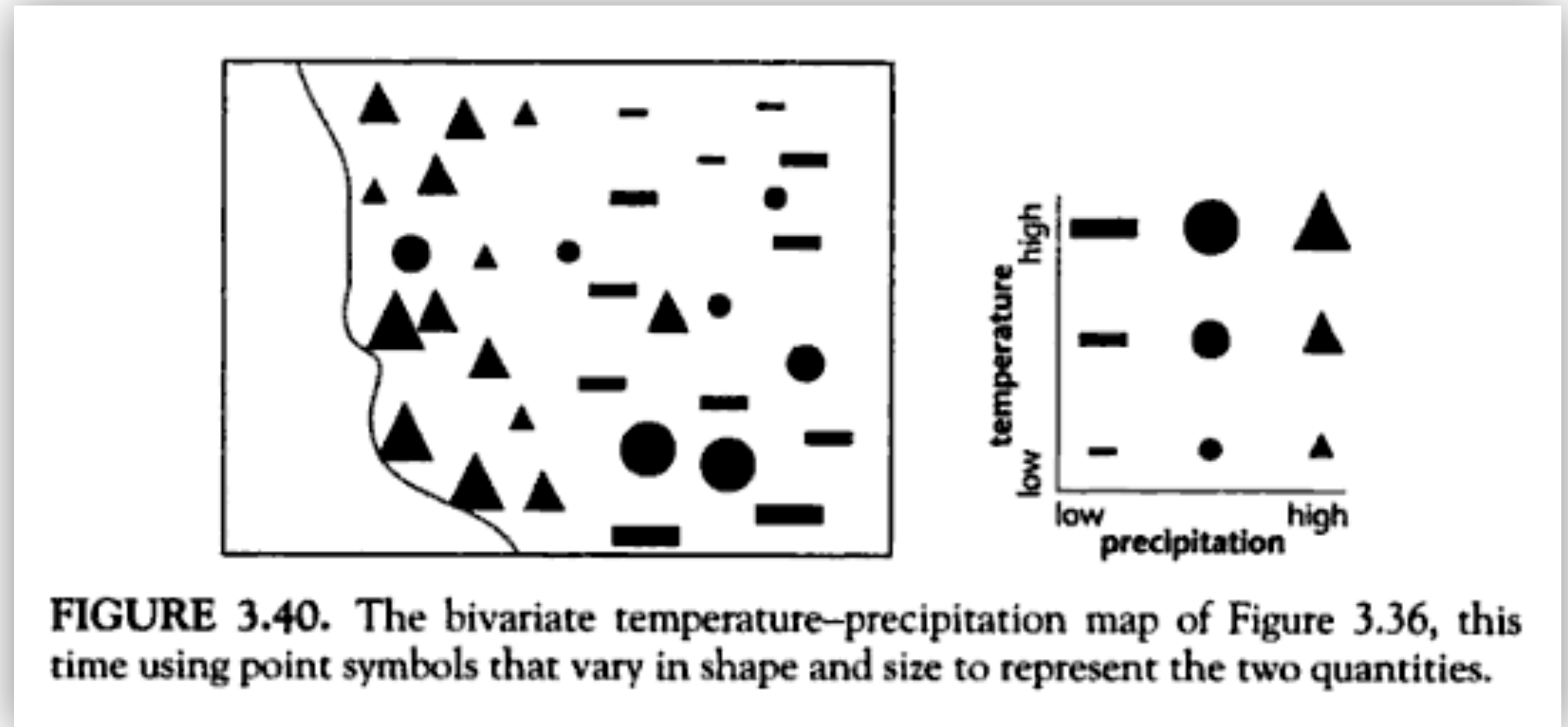
No interference or gain

Integral:

Both interference and gain

Configural:

Only interference, no gain



[MacEachren 1995]

Example: Stroop Effect

Separable:

No interference or gain

Integral:

Both interference and gain

Configural:

Only interference, no gain

blue

yellow

red

green

orange

purple

Example: Stroop Effect

Separable:

No interference or gain

Integral:

Both interference and gain

Configural:

Only interference, no gain

blue

yellow

red

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Example: Stroop Effect

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Example: Stroop Effect

Separable:

No interference or gain

Integral:

Both interference and gain

Configural:

Only interference, no gain

Asymmetric:

One dimension separable
but not the other

blue

yellow

red

green

orange

purple

Example: Stroop Effect

Separable:

No interference or gain

Integral:

Both interference and gain

Configural:

Only interference, no gain

Asymmetric:

One dimension separable but not the other

blue

yellow

red

green

orange

Takeaway: take care when combining visual features, and make use of redundant encodings!

Signal Detection

Magnitude Estimation

Pre-Attentive Processing

Selective Attention

Gestalt Grouping

Separability: how much interaction occurs between attributes?

Signal Detection

Magnitude Estimation

Pre-Attentive Processing

Selective Attention

Gestalt Grouping

Organization: how do we group visual elements?

Gestalt Principles

Figure / Ground

Proximity

Similarity

Symmetry

Connectedness

Continuity

Closure

Common Fate

Will highlight most relevant ones for vis, not all of them

Gestalt Principles

What's in the foreground?

Figure / Ground

Proximity

Similarity

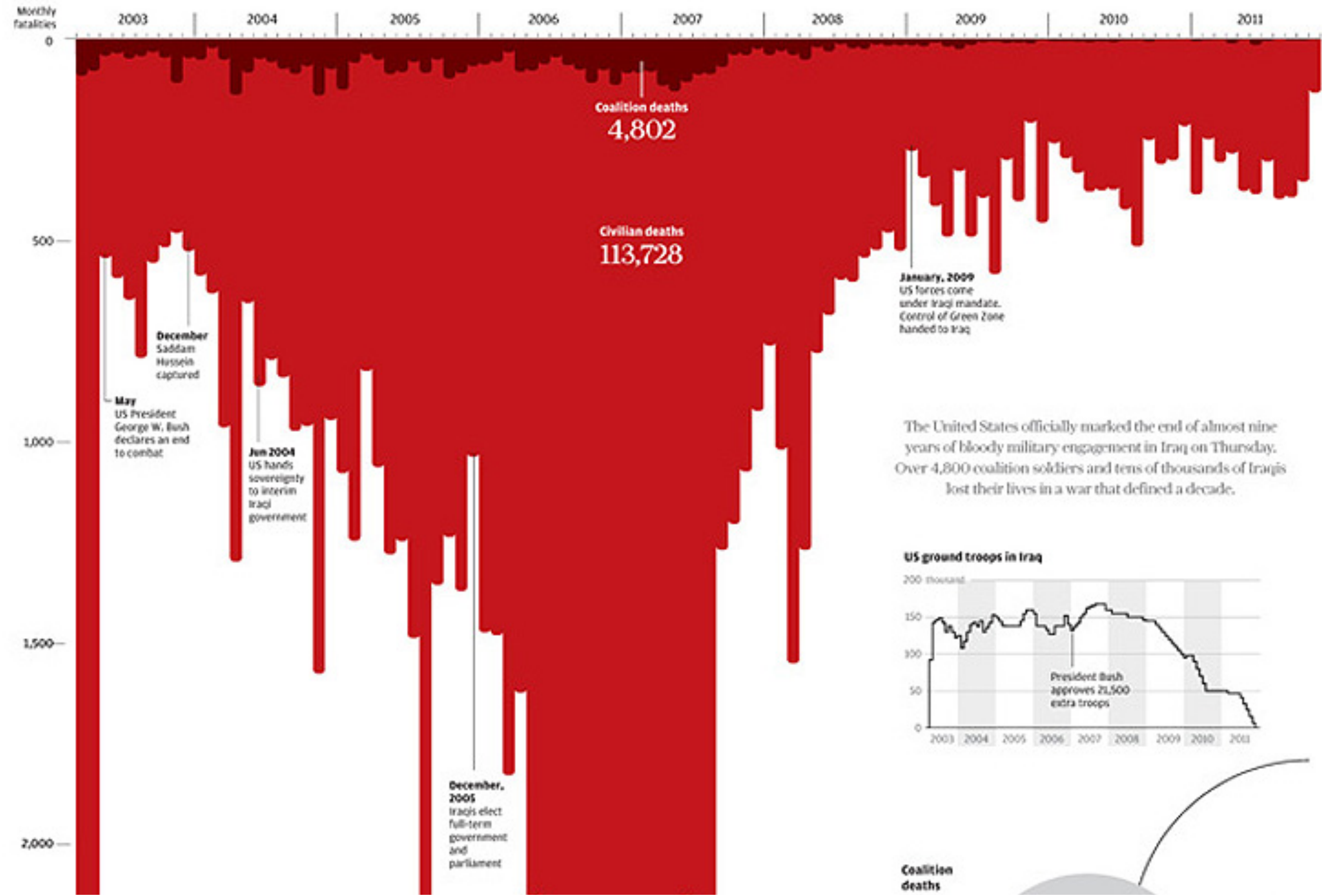
Symmetry

Connectedness

Continuity

Closure

Common Fate



Gestalt Principles

What's in the foreground?

Figure / Ground

Proximity

Similarity

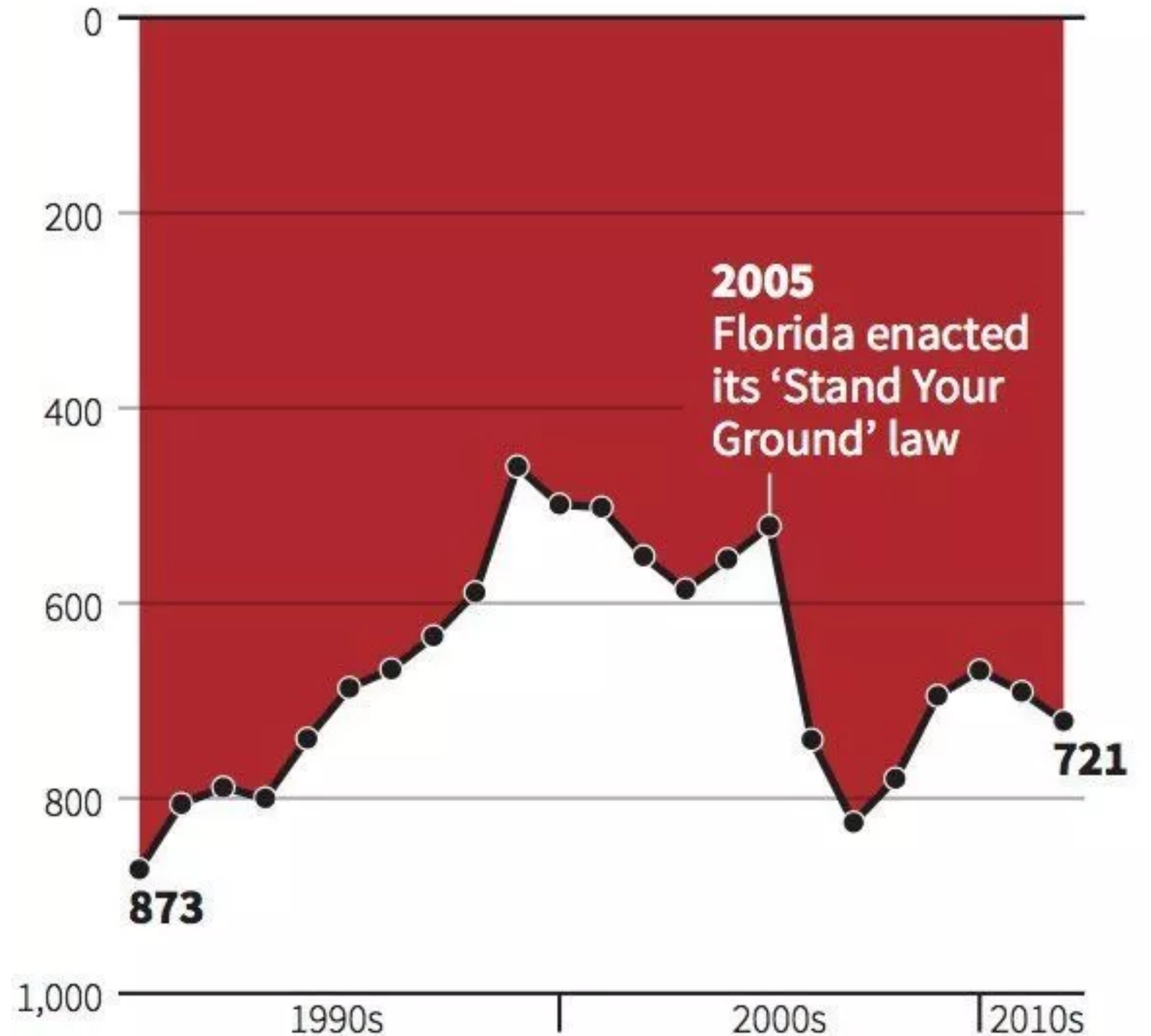
Symmetry

Connectedness

Continuity

Closure

Common Fate



Gestalt Principles

Figure / Ground

Proximity

Similarity

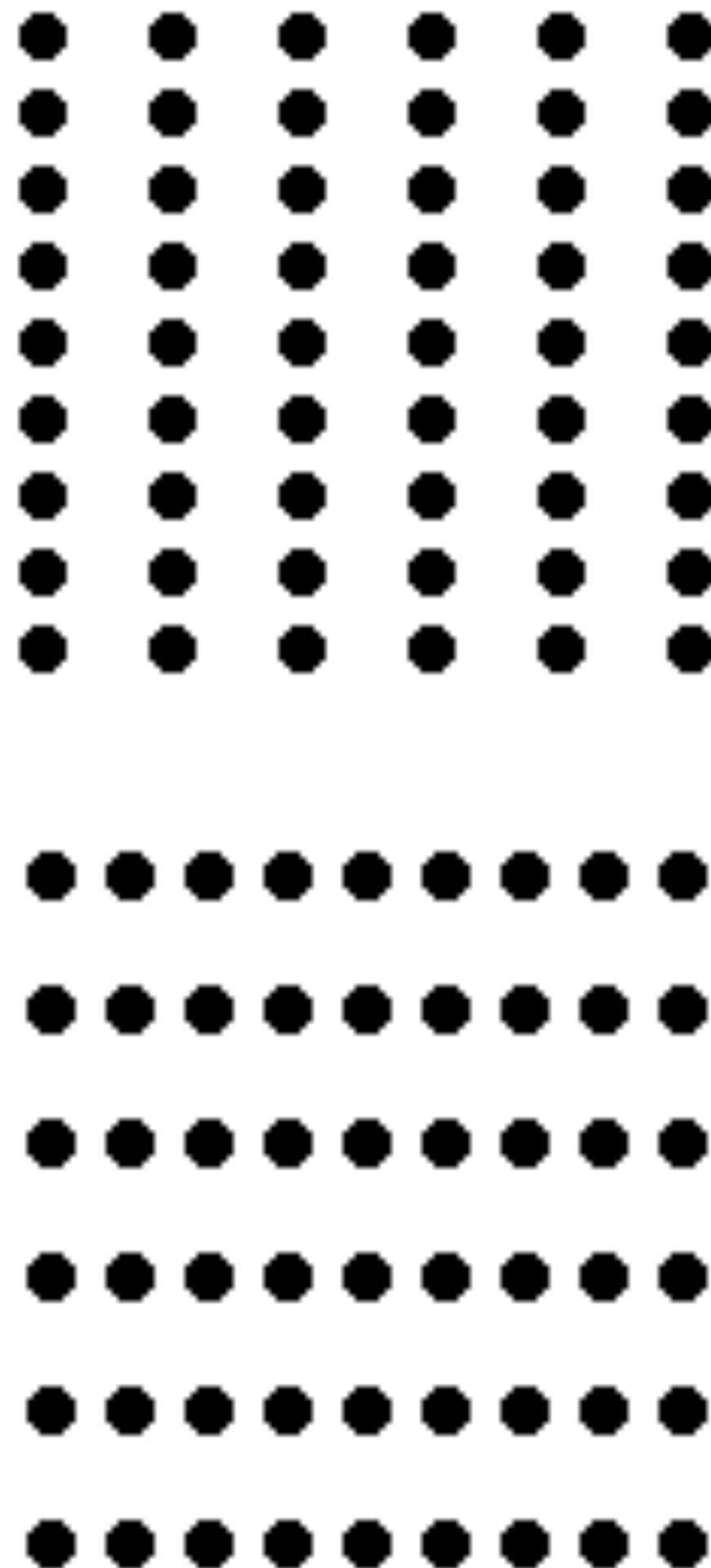
Symmetry

Connectedness

Continuity

Closure

Common Fate



Driving Shifts Into Reverse

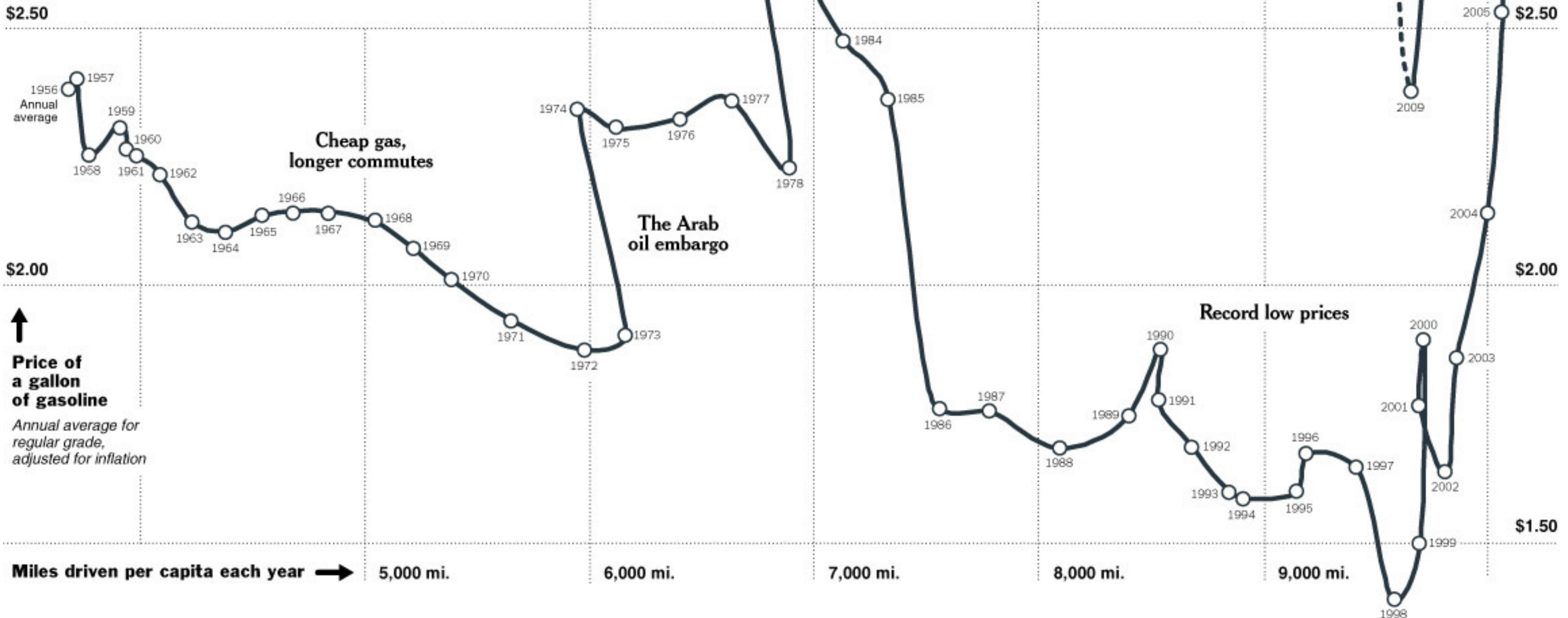
ECONOMISTS have long studied the relationship between driving habits and gasoline prices. Low gas prices can bring periods of profligate driving, and a quick jump in prices can cause many vehicles to languish in garages.

Until recently, Americans have driven more each year than the previous one, with a few brief exceptions. In 1956, Americans of driving age drove about 4,000 miles a year, on average. Fifty years later, that figure had climbed above 10,000.

But the latest recession has caused some big changes. High unemployment meant that fewer people were driving to work, and a slump in consumer spending

meant that less freight needed to be moved around the country. As gas prices soared in 2005, the number of miles driven — including commercial and personal — began to fall, and continued to drop after 2008 even as gasoline became cheaper.

“People were surprised by the very rapid rise in gas prices, and they changed their driving behavior,” said Kenneth A. Small, a transportation economist at the University of California, Irvine. “But my suspicion is that it is temporary. As soon as unemployment gets back to pre-recession levels, we will see Americans doing a lot more driving again.”



Gestalt Principles

Figure / Ground

Proximity

Similarity

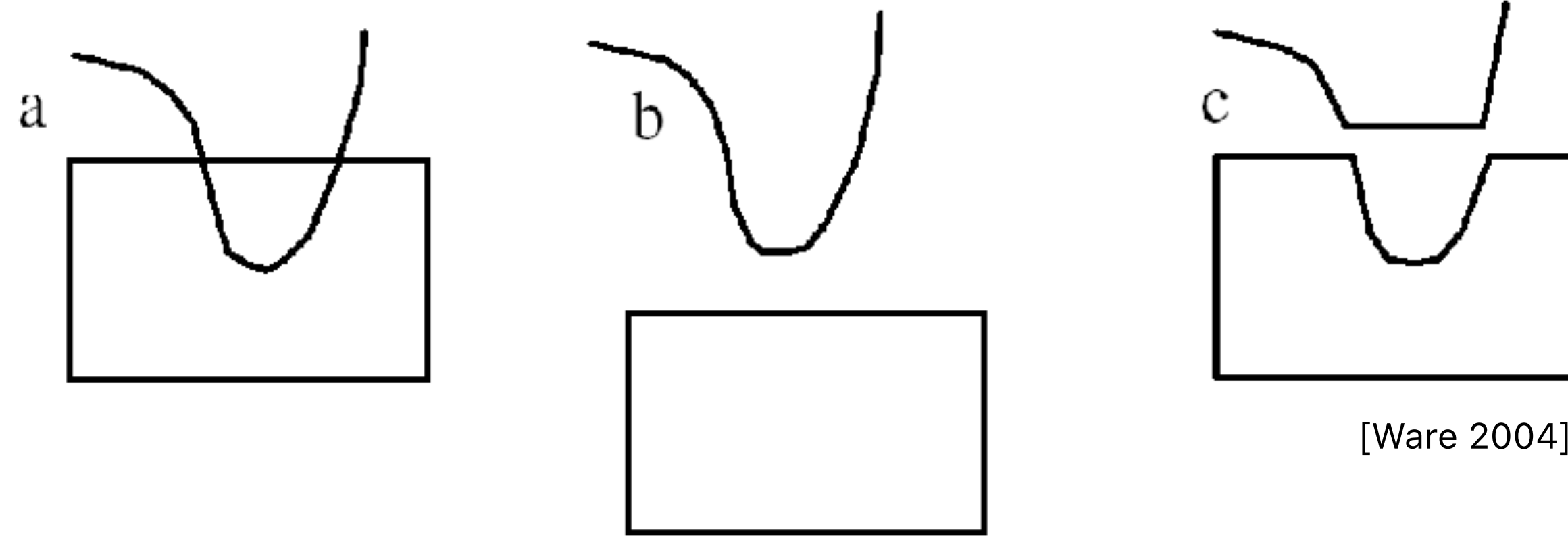
Symmetry

Connectedness

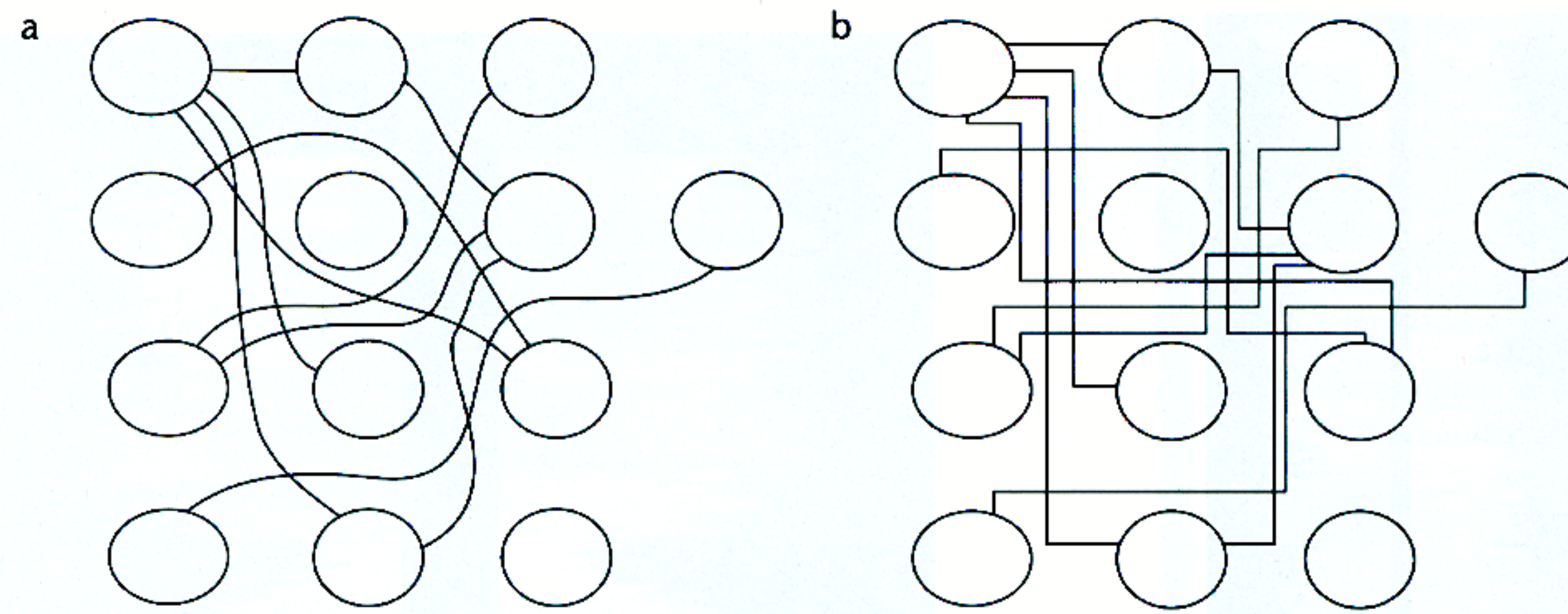
Continuity

Closure

Common Fate



We prefer smooth, not abrupt, changes.



Connections are clearer with smooth contours.

Gestalt Principles

Figure / Ground

Proximity

Similarity

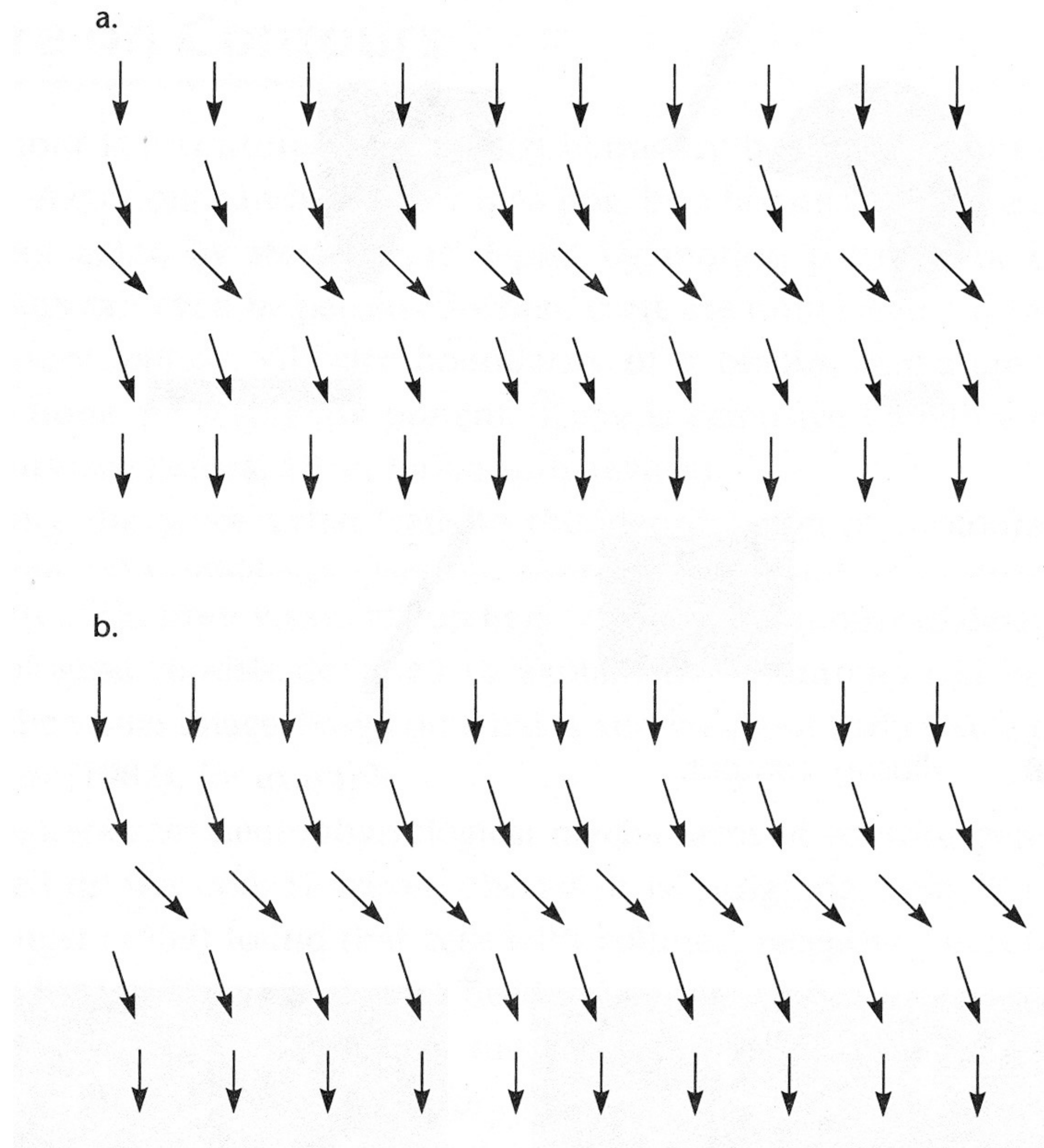
Symmetry

Connectedness

Continuity

Closure

Common Fate



Prefer field that shows smooth continuous contours

Gestalt Principles

Figure / Ground

Proximity

Similarity

Symmetry

Connectedness

Continuity

Closure

Common Fate



Dots moving together are grouped.

Gestalt Principles

Figure / Ground

Proximity

Similarity

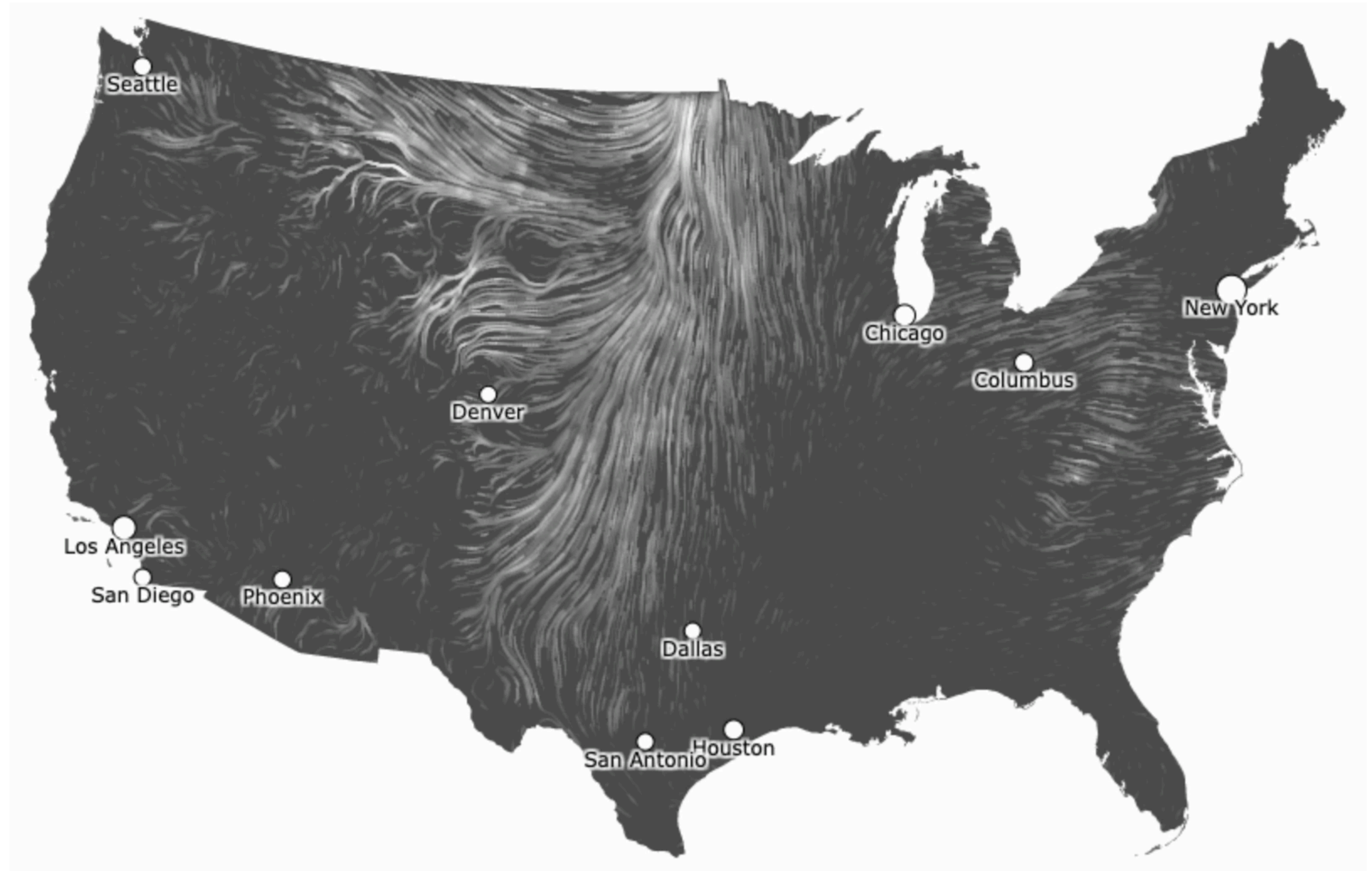
Symmetry

Connectedness

Continuity

Closure

Common Fate



Signal Detection

Use 4-5 steps for most channels, hard for people to distinguish more

Magnitude Estimation

Even a direct map to e.g. area or brightness won't always work.

Pre-Attentive Processing

Use channels that are pre-attentive for callouts e.g. position, color.

Selective Attention

...but be careful with combinations of channels!

Gestalt Grouping

Use these to improve annotations, coloring, animations.